Review Article

EFFECTS OF FOOD PROCESSING ON THE VITAL NUTRIENTS PRESENT IN THE FOOD: A REVIEW

Abstract:

The processing of food is a common method that converts raw materials into edible items that are safer, simpler to prepare and frequently more appealing to customersthis change, however has implications for the nutritional composition of meals It is used to describe the effects of different processing methods on vitamins, minerals and macronutrients etc. Understanding these consequences is critical for establishing healthy eating habits and improving public health. By refrigerating, below freezing, fermenting, drying, and adding salt or sugar, pathogen development can be decreased or prevented,pathogens can also be killed by using heat treatments such as pasteurization, sterilization and frying because these precautions help to safeguard customers, the majority of food-borne disease incidents involve pathogen-contaminated raw animal products, fruits, and vegetables, and so on. Food processing's function has varied over time, High-intensity economically processed food frequently has more added sugar, salt and calories, in addition to a lower micronutrient density than comparable food or meals cooked at home from raw or lightly treated sources food processing entails a number of procedures that might have an influence in the quality of food, especially nutritious quality as well as food safety heating and spray drying are all examples of food processing operations these processes can affect the content and quality of fats, vitamins, carbohydrates and proteins etc.

Keywords:
Thermal processing, Sterilization,Food processing, Nutrients, Spray drying**.**

Introduction:

The most basic requirement for all living things in the cosmos is food. Each person's existence depends on the foods they eat to maintain a balance between their physical, mental and biological health. Whether food deterioration is caused by bacteria or other factors, food serves as one of the greatest culture mediums for many microbes that causes it. It includes an enormous variety of goods, material, and cooking techniques that have developed through millennia, representing the diversity of human communities and environments. Food contains a variety of nutrients necessary for sustaining life, fostering growth, and assuring the appropriate operation of the body's physiological systems, including as water,

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carbohydrate, proteins, fats and minerals. The primary source of energy used by humans is carbohydrates. Polyhydroxy alcohols known as carbohydrates have potentially active carbonyl groups that can be either aldehydes or keto groups Carbohydrates are classified into four types based on the number of carbon atoms they contain: monosaccharides, disaccharides, oligosaccharides and polysaccharides (6). The most significant carbohydrate in an individual's body is glucose. Complex carbohydrates, such as starch, and dextrin, are hydrolysed to produce glucose. The body receives its energy from glucose, which is present in the blood. Additionally, the body's breakdown of glycogen produces glucose. Fructose is a monosaccharide found in fruits (6). Disaccharides are composed of two sugars linked by a glycosidic bond. Examples of disaccharides include: Sucrose contains fructose and glucose; it is a non-reducing sugar that occurs naturally in plants The two main sources of sucrose are apricot and pineapple, Maltose- Another name for maltose is malt sugar. It has two glucose molecules within, connected by glycosidic bond, Lactose- Mostly present in milk so it is known as milk sugar Glucose and galactose, two smaller molecules, combines to form the larger sugar molecule known as lactoseStarch-Starch is composed of amylose and amylopectin, Amylopectin (80-90%) and amylose (10-20%) are both present in starch. When combined with iodine solution, starch turns blue, Glycogen- The body stores glucose in the form of glycogen, which is found mostly in the liver and skeletal musclesit is comparable to plant starch, Cellulose- Beta-D-glucosea kind of sugar makes up the links in the chain of cellulose. It is the structural component of plant cell walls and make up more than 50% of the carbon in vegetation as a result, cellulose is the most common organic compound found in nature (6).Proteins are often used in the food industry to create a variety of healthy diets that match nutritional requirements Proteins are composed of amino acids, which are necessary to human wellness at all ages Dietary proteins are the primary source of nitrogen. Amino acids act as a foundation for body tissue and aid in the production of physiological enzymes that are necessary for managing chemical and biological process responses in order to maintain optimal bodily function basically there two types of proteins: Essential and Non-Essential proteinEssential proteins are those that an organism requires to survivebut non- Essential proteins may nonetheless serve crucial purpose despite not being essential for existence. Examples for Essential proteins: Insulin, Haemoglobin and DNA etc. Examples for Non- essential proteins: Collagen, Melaninetc.Fatty acidsare hydrocarbon chains with a carboxyl group at one end. They are known as acidsbecause of the latter (carboxylic acid) Saturated means there are no double bond in the hydrocarbon chain because it is saturated, which occurs when all of the carbon atom are linked to as many hydrogen atoms as possible Acetic acid, propionic acid, and butyric acid are examples of saturated fatty acids. It is evident that vitamins and minerals are essential components of nutrition and play a crucial role in preserving health. Unfortunately, some of them have average consumption that is either too high or too low diseases may develop over time as a result

of improper supply that is out of alignment with standards the quality of nutrition and the health of both individuals and entire groups can be evaluated and improved with the use of data collection on people's average consumption hypovitaminosis, a vitamin shortage, causes a number of irregularities in how the body functions. food processingis the physical or chemical transformation of basic materials into food or other forms that may be easily consumed by the customer. Pickling, pasteurization, and many other kinds of conservation, canning even other packaging, muttering and macerating, melting, emulsifying and heating (including boiling, grilling, cooking, or sizzling) are all popular food processing procedures (30). Fresh meals degrade faster than processed foods, and processed commodities are more suitable for long-distance transfer from producer to consumer food processing (including preparation) enhances nutritional content, safety, flavour, and shelf life. Although there are numerous benefits to processing, it may also be damaging and lower the nutritional content of food.for example, Blanching causes vitamin and mineral leaching lossesFurthermore, mineral material displacement may occur during processing of grinding, and extrusion(56).

Food Processing:

The transformation of basic components into edible or marketable meals by diverse physical, chemical, and mechanical processes is referred to as food processing (30). This industry plays a crucial role in providing safe, convenient and shelf-stable food items for consumers worldwide(68). Food processing is an integral part of our daily lives, impacting not only our diets but also our economics health and environment(3) The collection of methods used to turn uncooked materials into edible goods is referred to as foodprocessing. It is essential for assuring the accessibility, safety and diversity of food.Since prehistoric times, the processing of food has been a vital part of the dietary production 226 chain that links produce from agriculture with the delivery of nutritious foods to consumers in its original state and at the time they require it (8). Making foods survive longer before they deteriorate has historically been the main motivation behind food processing and preparation. Food processing began about the time our forefathers "discovered" cooking by lighting food on fire. Then followed preservation with salt, drying, fermenting, and other early methods of food processing, which eventually gave rise to contemporary food processing and modern processing techniques provide us with a plentiful, secure, convenient, inexpensive, and wholesome food source(10).Processing foods, on the other hand, have a considerable influence on food quality, including nutritional quality and food safety other processing methods, such as fermentation operations, can be utilized to enhance food quality on the other end of the spectrum However, most processing methods reduce the fundamental features and nutritious value of food. Food processing can make it safer to eat by removing poisons and inhibiting or eradicating germs (27). Pathogen

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growth can be reduced or stopped by refrigerating, cooling, undergoing fermentation, being dried and added salt or sugar. Heat procedures like as pasteurization and frying can be used to kill pathogens. Because these measures help protect consumers the bulk of food-related illness cases concern pathogen-contaminated raw animal byproducts, fruits and vegetables etc (57).The purpose of food processing has evolved over time. High-intensity economically processed food frequently contains more added sugar, salt and calories, as well as a reduced micronutrient density than equivalent food or meals prepared locally using raw or lightly processed foods (28).

The Evolution of Food Processing:

People and their forefathers have encountered difficulties in getting and eating raw foods across human history They lacked the specialized of a fast hunter and did not digest plant components efficiently as omnivore animalsas a result, humans have sought and created methods, techniques and innovations to improve the accessibility of food, digestion, safety, transportability and shelf life (31). In The early 19th century marked a significant turning point in food processing with the invention of canning by Frenchman Nicolas Appert His discovery, inspired by a need to preserve food for Napoleon's armies, involved sealing food in airtight containers and subjecting them to heat This technology not only extended the lifespan of food but also made it more accessible, especially on long maritime trips Canning helped to feed troops and people during times of war and exploration, revolutionizing the food business. Aside from eating more animal-based foods, such as animal products, it is assumed that nonthermal food processing, such as beating, chopping, crushing or drying in the sunlight played a role in archaic people's increased nutritional qualitythe food processing sector flourished throughout the 20th century continued to evolve, introducing convenience foods and thermal processing methods including Microwaveovens, freeze-drying, spray drying, canning,sterilization and the introduction of ready-to-eat meals transformed the way people prepared and consumed food. Fast food chains like McDonald's and the proliferation of processed snack foods became emblematic of this era (58). Thermal processing became important in terms of energy use at some point evidently, the use of fire rendered raw meat and carrion palatable, safe and tasty furthermore, cooking improves the nutritional content of grains, tubers, legumes and other plant foods through the process of gelatinization, denaturation of antinutrient components and starch denaturation(28).

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Table 1: Effects of food processing on different food materials

Food category	Food Processing Method	Effects of Processing	References
Fruits& Vegetables	Canning	Preservation of shelf life	(50)
	Freezing	Retention of nutrients and texture	(48)
	Drying	Extended storage life	(47)
Meat and Poultry	Smoking	Flavour enhancement	(60)
	Curing	Preservation and flavour	(55)
Cheese	Pasteurization	Killing harmful bacteria, extending shelf life	(49)
	Heat treatment	Decrease the level of moisture content and protein content	(59)
	Homogenization	Uniformity of milk fat particles	(66)
Grains& Cereals	Milling	Grinding into flour	(40)
	Fortification	Addition of nutrients (e.g., vitamins, minerals)	(40)

Beverages	Brewing (e.g., beer)	Fermentation of grains, development of alcohol and flavours	(16)
	Pasteurization (e.g., milk)	Preservation kills microorganism	(16)
Pasta	Freeze Drying	Influence on the quality of pasta and its rehydration qualities	(43)
	Fortification	Effects on the nutritional value of pasta	(53)
Kimchi	Fermentation	Effects on the texture, sourness& microbiological populations of kimchi	(32)
	Salting	The influence on microbial development and preservation Influence on the saltiness and texture of kimchi	(32)
Yogurt	Pasteurization	Effects on the probiotic content and yogurt culture viability	(63)
	Fermentation	The effects of fermentation on duration and temperature	(29)

Bread	Straining	Whey is removed to provide a thicker texture. Mouthfeel &creaminess are affected.	(17)
	Fortification (Vitamin D)	Increases the vitamin D serum status thus prevents the vitamin D deficiency	(54)
	Fermentation	The role of fermentation in the leavening of bread and make Bread texture and flavour development	(25)

Different food processing methods have various effects on nutrients present in the food including both positive and negative effects (Table 1). Food processing techniques affects the food in various ways including taste augmentation, texture retention and othersforexample, in pasta freeze drying and fortification can be done& the effect of freeze drying influences the quality of pasta and its rehydration qualities whereas fortification influence the nutritional value of pasta. In bread, fermentation influences bread texture and flavour development. Yogurt is a fermented dairy product that is popular for its probiotic characteristics and health benefits. It is critical to comprehend the different elements that influence the manufacturing process, quality, and health-related characteristics. Pasteurization is an important stage in the manufacturing of yogurt. It entails heating the milk in order to destroy dangerous bacteria, which is necessary to assure the security and potency of the finished yogurt product understanding its impact on bacterial quantity and yogurt culture survival is critical for producers and customers interested in yogurt's health benefits. Fermentation is the method by which milk is converted into yogurt by the activity of probiotic microorganisms. It is critical to comprehend how fermentation influences the time and temperature of fermentation since these parameters can alter the flavour, appearance, and microbial content of yogurt. Straining yogurt is a process for removing whey, leading in a thicknessthis stage has the potential to change the texture and

smoothness of yogurt, which is critical for people who like certain textures in yogurt. Fortification, the adding of nutrients to yogurt to improve its health benefits is referred to as fortification Understanding the impact of fortification on yogurt's health benefits is critical for anyone trying to include yogurt into an appropriate diet that meets particular nutritional goals. Microbes that are beneficial (like the lactic acid bacteria) serve an important role in the breakdown of carbohydrates and the production of organic acids during fermentation This process not only gives kimchi its distinctive tangy flavour and sourness, but it also affects the way it feels by softening the veggies through enzyme activity. Furthermore, the shift in microbial populations during fermentation aids in kimchi preservation by limiting the growth of dangerous bacteria. Brewing involves the fermentation of grains, typically barley or wheat, to produce beer. During fermentation, yeast consumes the sugars present in the grains, converting them into alcohol and carbon dioxide this process is well-established and has been a fundamental aspect of brewing for centuries Pasteurization is a heating procedure used to eliminate unwanted microorganisms in food and drinks, such as milk, including as bacteria and pathogens this is critical for food safety since it increases the duration of storage of the item and lowers the possibility of foodborne disease. Canning makes sense for vegetables and fruits since it increases their shelf-lifefreezing is warranted since it helps fruits and vegetables maintain their nutrition and texture. Drying is a viable way of preserving fruits and vegetables since it enhances their storage life. Smoking is acceptable because it improves the taste of poultry and meat. Curing is warranted since it full fills the twin objective of meat preservation and taste improvement. Milling grains and cereals in flour represents a critical stage in the preparation of many food products, notably baked dishes such as bread, pastries, and pasta milling reduces whole grains to smaller particles, increasing surface area for activities that include digestion, cooking, and taste development.Fortification refers to the addition of important elements such as minerals and vitamins to grains and cereal-based goods this procedure is critical for combating nutritional deficiency in populations many people rely heavily on cereals and grains as part of their daily diet and fortification ensures that they get enough nourishment for example folic acid added to flour made from wheat may prevent birth abnormalities while iron added to cereals can help treat anaemia. Extrusion is a flexible procedure used to shape and produce a variety of grain and cereal-based goods this method enables the production of a broad variety of items including grains, pasta, and food for snack it is utilized in various items to produce certain textures, forms and cooking qualities, hence increasing their market appeal.

Effects of food processing on Vitamins:

Vitamins are essential micronutrients that play critical functions in a variety of physiological processes inside the human body they are mostly obtained

through diet however food processing methods might affect their bioavailability vitamins areclassified into two groupswater-soluble and fat-soluble vitaminsfat-soluble vitamins are kept in the liver, fatty tissue and muscles of the body vitamins A, D, E, and K are fat-soluble vitamins,in the presence of dietary fat, these vitamins are more easily absorbed by the body,water-soluble vitamins do not accumulate in the body it includes vitamin C and all of the B complex vitamins.Vitamin B Complex: B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6 (pyridoxine), B7 (biotin), B9 (folate), and B12 (cobalamin) are all water-soluble vitamins.VitaminB1,it is also known as thiamine and it is a water-soluble vitamin that is susceptible to a variety of conditions, especially processing techniques.The effects of processing on vitamin B1 can lead to its degradation or loss. High temperatures can lead to the degradation of vitamin B1. Cooking, pasteurization, and canning at high temperatures can result in significant losses of thiamine boiling can cause up to 50% of the thiamine content in food to be lost.Vitamin B2, commonly known as riboflavin, is another water-soluble vitamin that may be found in fruits and vegetables affected by various processing methodsriboflavin is relatively stable to heat, especially compared to some other B vitamins like thiamine (vitamin B1) while cooking and food processing may cause some minor losses of riboflavin, these losses are generally not significant and a substantial portion of the vitamin often remains in the food. However, prolonged exposure to high temperatures can result in greater riboflavin degradation(14).Vitamin A is required for normal eyesight, immunological function and skin health t is found in food in two forms: prepared vitamin A (retinol) and provitamin A carotenoids (for example, beta-carotene) cooking and processing can affect the bioavailability of both forms while some processing methods can improve the release of vitamin A from plant sources, others may cause degradation.Vitamin C, commonly referred to as the antioxidant ascorbic acid is a water-soluble vitamin that is susceptible to a variety of processing methods, such as heat, light and air exposure,the effects of processing on vitamin C can lead to its degradation, reducing the vitamin's nutritional value in food products reduction during storage and also from drying, oxidation etc (56).Furthermore, vitamin C improves the uptake of iron and strengthens the immune system(41).Cooking degrades vitamin C greatly since it is heating sensitive depending on the temperature, length and kind of food being cooked, boiling, steaming and microwaved can result in losses ranging from 15% to 55%(11). Processes using high temperatures like as canning and pasteurization, can also result in large vitamin C losses,it might range from 30% to 80% depending on the time and temperature of processing.Vitamin E is a fat-soluble vitamin which serves defend cells from oxidative damage it may be found in a variety of foods and is an important nutrient for human wellness however, food preparation can have a considerable influence on vitamin E concentration and stabilityheat represents one of among the most often utilized processing processes in the food sector(33). vitamin E is heat-sensitive and its concentration can be greatly decreased during boiling or pasteurization, it was discovered that boiling

reduced the vitamin E content of vegetables by up to 50% it was also discovered that the time and temperature of the heating had a significant impact on the level of vitamin E breakdownwhen opposed to heat treatment, freezing is often seen as a gentler processing approach nonetheless it might result in some vitamin E losses(56). Vitamin K is a fat-soluble vitamin that is necessary for healthy blood clotting and bone metabolism,Vitamin K1 (phylloquinone) and vitamin K2 (menaquinone) are the two primary types although vitamin K can be discovered naturally in a variety of foodsthermal processing including heating and pasteurization, can have an impact on dietary vitamin K concentrationaccording to research, vitamin K1 is very heat stable with low degradation throughout cooking the long-term stability of vitamin K2 on the opposite hand might vary depending on the temperature and time of the heat treatment(65).

Effects of processing on proteins:

Proteins are important that perform vital functions in a variety of biological activities from accelerating chemical processes to offering structural supportproteins are macromolecules that are made up of amino acid chains that have been folded into unique three-dimensional structures (1).The linear arrangement of amino acids is referred to as primary structure alpha-helices and beta-sheets are secondary structures generated by hydrogen bonding inside the chain,proteins can be denatured by heat processing procedures such as frying, baking and pasteurization (9). Protein molecules expand and lose their natural structure at high temperatures resulting in changes in texture, taste and digestion heat, on the other hand can increase the digestibility of particular proteins, thereby rendering them more absorbable.The Maillard reaction which happens during high-temperature cooking can result in the creation of protein-lysine and protein-arginine adducts (19).This reaction can cause browning of food items changes in taste as well as modifications in digestibility of proteins and allergies,extrusion processing is commonly used to manufacture snack foods and breakfast cereals (35). The high temperature and pressure during extrusion can disrupt protein structures, affecting their solubility, functionality and nutritional value extrusion can also lead to protein denaturation and reduced protein digestibility through the activity of particular bacteria and enzymes.Fermentation techniques such as cheese and yogurt manufacturing can enhance protein digestibility fermentation can also produce peptides that are bioactive with potential health advantages (22). processing under high pressure is a non-thermal approach that can better maintain protein structure and functioning than typical thermal procedures HPP can inactivate bacteria and enzymes that cause protein breakdown while preserving protein nutritional quality (1).

Effects of processing on fats:

Dietary fats are a broad range of lipids that perform vital functions in the body such as storing energy, insulating material and cell membrane formationfood processing includes a number of processes that can have a substantial influence on the composition and purity of dietary fats deep-frying includes submerging food in hot oil, which results in fat absorption and possible destruction owing to high temperatures (59).When frying oils are used repeatedly, oxidation products and polymerization can occur, impacting both the nutritional content as well as the security of the fatto address these concerns innovative frying techniques and oil management techniques have been created,canning and other techniques of food preservation can affect the composition of lipids of foods, possibly altering flavour, textureand nutritional valueproper conditions for storage are critical for preserving canned food quality and minimizing lipid oxidation. Extrusion is a high-temperature, high-pressure manufacturing procedure extensively employed in the creation of snack foodsextrusion can cause fat breakdown and changes in fat physical characteristics influencing product texture and shelf lifethese impacts can be mitigated by formulation changes and process improvement (51).The process of converting vegetable oils in liquid form into solid fats is known as hydrogenation trans fats, that have been associated to an elevated risk of heart disease can be produced through partial hydrogenation(45).

Table 2: Positive impacts of food processing processes on different nutrients present in food

Nutrients	Beneficial effects	Food Processing method	References
Vitamin A	Abetter absorption	Homogenization (Milk)	(14)
Vitamin B12	Elevated levels	Fermentation (Dairy products).	(65)
Vitamin C	Llessvacuum ~~spoilage~~sealedspoilage	Freezing (Fruits & Vegetables).	(33)
Folate	Enhanced bioavailability	Fortification (Cereals, orange juice)	(13)

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Protein	Greater digestibility	Cooking (Meat, beans, eggs)	(1)
Calcium	Increased absorption	Fortification (milk, orange juice)	(34)
Zinc	Increased absorption	Fermentation (*Phaseolus vulgaris L*)	(20)

Every nutrient plays a particular role in food and thesenutrients have good effects on food processing processes (table 2) the process of homogenization reduces the size and uneven distribution of the milk's fat globules vitamin A, a fat-soluble vitamin, can be better absorbed by doing this. Microorganisms are used in the fermentation process to transform carbohydrates into other compounds like acids, alcohol and gasessome fermentation processes can result in the creation of vitamin B12, a component which is not normally found in plant foods, vitamin C is a water-soluble vitamin so it candissolve easily in water by delaying the enzymatic processes that break down vitamin C in fruits and vegetables, freezing can help to maintain vitamin C levels. Vitamin B folate is crucial for the development and proliferation of cells foods that lack natural nutrition are fortified by adding additional nutrients adding folate to grains and orange juice can help people consume more of this vitamin a form of carbohydrate known as fibre is indigestible to humans while grinding and refining can reduce the amount of fibre in grains, they can also increase the amount of remaining fibre that is soluble or dissolves readily in water this may facilitate the body's absorption of the nutrients included in grains the proteins in animal products, legumes, and eggs can be broken down during cooking to make them simpler for the body to digest. Additionally, this can aid in the release of some of the vital amino acids present in these foods live microorganisms known as probiotics naturally yoghurt and kefir both contain probiotics as a result of fermentation by destroying bad bacteria and creating chemicals that are good for the gut lining probiotics are believed to boost gut health.

Unlocking the potential of thermal processing:

The determination of the heating temperature necessary to generate items with acceptable eating quality while remaining microbiologically safe is referred to as thermal processing typically, thermal process includes heating food for a particular purpose with the goal to eliminate microorganisms that endanger public health suppress digestive enzymes that degrade food during

preservation regarding processing and packaging, the basic idea of food in-container sterilization has undergone a significant alternation the food sector now employs process. Material which should preserve the food are developed into shapes of bottles, cans, pouches and laminated containers the foods that were once known as canned or bottled goods are knowns as heat preserved or thermally processed goods a time temperature schedule is being used here to describe the ambient temperature of the medium that heats and the duration of the process (46). Food's macronutrients are lipids, proteins and carbohydrates during heat processing, complicated interactions between carbohydrates, lipids, and proteins result in a wide range of complex byproducts that are either directly or indirectly related to protein changes.

Caramelization, the Maillard process, oxidation fat lipid and protein oxidation are among the reactions that have drawn the most attention and concern. Their complex byproducts or phases have been found to significantly impact the characteristics and structure of proteins (23). The act of eliminating moisture from a fluid or solid meal by evaporation is known as drying or dehydration.

Foods are subjected to pasteurization, a gentle heat treatment, with the goal of eliminating specific vegetative microorganisms and deactivating the enzymes that lead to deterioration with little modification in the desired food qualities typical pasteurization temperature ranges from 60 to 90 degree Celsius for a predetermined period of time. The processing time needed decreases as temperature rises. A crucial step in the food and beverage sector is sterilization. They protect against dangerous microbes, enzymes and spoiling agents and increase shelf life for products. Many people use traditional thermal sterilization techniques to preserve fruit juice, Ultra-high-pressure sterilization (HPS) is a revolutionary sterilization technique that enables the processing of many food types in continuous fluid while effectively inactivating pathogenic and most spoilage-causing microorganisms. Among the primary advantages of HPS include the fact that it causes fewer functional and fruit juice's nutritional qualities, such as its antioxidant capacity, phenolic composition, provitamin A concentration and vitamin C content, when compared to commonly applied heat treatments (62). The pasteurization of beverages occurs either during or before packaging. The latter technique works well for products that are temperature-sensitive. Pasteurization can be carried out either in batch mode or continuously. Pasteurization in batches requires less longer process time and higher temperature.

Canning is a thermal technique that involves packing food in tightly closed vessels and then cooking it to remove germs as a component of the conventional canning procedure heat application's major purpose is to kill hazardous and spoilage germs while also avoiding leakage through the hermetic container and preventing the caused by new bacteria the quantity of heat applied to a food is determined by a variety of factors, including the

product's density, composition, heat transfer resistance, and the heat resistance of any essential food-borne bacteria, starting microbial load, container, heating medium and apparatus, methods, and so on. Heat-treated canned goods are cooling followed by handling at room temperature maintaining the integrity of containers and preventing product contamination.(4). In the canning industry, there are essentially two types of heat procedures the first method relies on the application of retorts (or autoclaves, traditional canning etc), whereas the second method relies on the aseptic processing of food. In procedures utilizing retorts, food is placed in containers, sealed, and then cooked using until both the container and the food become steam under pressure combined sterilization. A liquid meal is sterilized using heat exchangers within the container in aseptic processing, and identical apparatus is used to cool it afterwards. After cooling, the sterile food is placed in a previously filled container and sealed. These procedures are performed in a sterile setting at room temperature using sterilized equipment.(12)

The most common techniques of food preservation are drying, since it is the easiest way to reduce a substance's water content traditional drying is frequently done in the sun light however it is thought to be less effective due to unreliable weather a multi-layer tray drier, which utilizes heated air in an enclosed room, is one of the inventions with the most simple and easy technique. Because the heated air comes into touch with the substance, direct drying occurs ingredients in food that are susceptible to Mold growth and are sensitive to heat can be protected with this technology. the drying action of a tray drier is complicated by a variety of factors. According to study, the most difficult factors are time, temperature, substance width, and air circulation rate. Despite the fact that the tray dryer has been the topic of multiple studies, none of them addressed concurrent changes in a period of time rate of flow, and substance width, all of these are critical(36).
It works on the basis of the convection drying process, which involves moving hot air over and around trays containing the material to be dried airflow consistency across all trays is guaranteed by the tray dryer's design to obtain reliable drying outcomes, this homogeneity is crucial to provide this airflow, fans or blowers are utilized. Accurate temperature regulation is essential the temperature in the chamber used for drying is precisely managed to meet the needs of the item being dried This control stops the product from being overheated or underheated, which can lead to inefficient drying or product damage. The moisture in the product evaporates as a result of the hot air's absorption of the moisture as it passes through the trays typically, the damp air is subsequently expelled from the drying chamber the placement of the trays ensures appropriate airflow between them. To guarantee consistent heating, perforated tray designs or trays with sieve bottoms are frequently utilized the main idea behind tray drying is to create a controlled environment with precisely regulated heat and airflow to eliminate wetness from the material quickly and evenly (2). The following are some common food items

that are frequently dried using tray drying, dried fruits like dates, fig and apricot, freeze dried fruits like strawberry and apples, vegetables like tomato, grains and cereals and nuts etc.

Drum drying is the application of fluid or slurry materials to the outside of the heated drum in the form of a thin, continuous coating this drum spins, exposing the material to the heated surface and hastening the evaporation of the fluid contained there in the solution or slurry material is fed onto the surface of a spinning drum this can be achieved using a variety of ways, depending on the qualities of the material, such as sprinkling, pouring, or spreading. The heated surface makes touch with the substance as the drum turns. The material's moisture or solvent is gradually removed by the drum's heat, leaving the dried product behind the material is subjected to the heat in an even distribution as a result of the drum's rotation, which promotes even drying a double drum dryer is made up of two similar diameter iron cylinders that circulate in opposing directions in close proximity to one another. The metal cylinders, which are fundamentally burned by saturated steam, come into contact with a thin layer of the material to be dried. Because the cylindrical structures reach elevated temperatures or heat the substance by conduction, the material dries quickly (24).

Spray drying: Liquids are converted into powders using the well-known industrial process of spray drying (61). A recent area of research focuses on spray-drying fermented foods to create stable powders on a big scale due in large part to the cooling effect of evaporation action, various food qualities, including as nutritional content, flavour and colour can be preserved during the spray drying process. The liquid streams are pumped into a drying chamber in the spray dryers, while the dissolved substance solidifies and the solvent evaporates. A spray nozzle is used to inject a liquid stream, and its size is regulated by the dimensions of the spray drier in laboratory-scale dryers, smaller nozzles are employed, whereas large-size nozzle assemblies are used in industrial spray dryers. The nozzle determines the size of the particle powder, viscosity, and composition of the range between 20 mm to 185 mm Desirable physicochemical properties include fluids and components that are critical in determining the atomizer setup as feed droplets quickly evaporate from their liquid state, powder is created the nozzle's size is typically made to produce droplets that are extremely tiny to maximize the rate of vaporization and heat transfer (38). Because of the rapid drying the product suffers less from thermal deterioration additionally, the spray drying procedure allows for the control of final product characteristics like 9particle size distributions, moisture content, and bulk density spray drying enables constantly high-capacity manufacturing of uniform particles with perfectly blended ingredients, for example, detergent drying the three primary stages of the spray drying process are atomization, solvent evaporation and particle collecting (42).

Process of atomization involves turning a fluid into fine spray there are three types of atomizers: revolving atomizers, hydraulic, pneumatic sprayers and nozzles. Surface tension, viscosity and density of the medium are all factors that affect how big the droplets that are created inside the chamber (61). Spray drying is a three-step process that starts with atomization moves on to droplet-hot air interaction and moisture evaporation and ends with separating a dry substance from the exiting air the most important phase in the spray-drying procedure is atomization, which converts the fluid supply into small droplets or particles the resulting decrease in particle dimension and ensuing dispersion of the fragments in the drying air causes the particle's surface area to increase exponentially to accomplish atomization, atomizers such as rotary atomizers, compression nozzles, dynamic sprayers, and acoustic nozzles are employed (38).Typically, ambient air is employed as a drying medium in the spray-drying process throughout the applying spray drying process, the ambient air is filtered using filtering system and then warmed in line with the operational requirements. Depending on how unstable or sensitive to oxygen the substance that is being dried is, additional inert gases such as nitrogen or argon may also be employed (15). Convection transports heat through the medium used for drying to the particles, where it is converted into absorbed heat when its humidity evaporates the degree of heat and mass transmission is affected by the diameter of the droplet as well as the speeds of the atmosphere and droplets (37).To prevent product loss in the environment, separation is typically performed using a cyclone mounted outside the dryer the coarsest particles are separated from the damp exit air by the cyclone, while the wet dense particles are collected towards the bottom of drying compartment (38).

Table 3: The effects of spray drying on nutrients are outlined below

Nutrients	**Effects of spray drying**	**Temperature effect**	**References**
Proteins (legume)	Extend the shelf life and improves the transportability of legumes.	Quality of food legumes is affected by heat	(18)
Vitamins (Fruits and vegetable juices)	Increases the shelf life and improves quality	High temperature destroys the enzymes and changes the colour	(64)

Fat (coconut oil)	Oxidise at high temperature.	Higher temperatures can speed up the oxidation of fat in oil	(21)
Minerals (Calcium Fortified milk powder)	Although most minerals are generallyresilient to spray drying, the pH of the feeding solution can have an impact onspecific minerals, including calcium etc	Mineral content is largely unaffected by temperature	(5)
Starch (doughnuts)	releasing antioxidants from fibres	Elevated temperatures strongly suppress taste	(39)
Sucrose (Powdered instant coffee)	effect on caramelization And makes the materials sticky at lower temperature	The progress of caramelization and the Maillard reaction can both acceleratedhigher temperatures.	(26)

Spray drying is a food preserving process that can lower moisture content hence extending product shelf life (table 3) Furthermore, it can improve product transportability by lowering bulk and weight this is essential in the context oflegumes since it makes storage and transit easierto protect the quality of legumes temperature must be carefully controlled during the drying process.Increases the duration of storage and improves the quality of fruit and vegetable juice this is an obvious advantage of spray drying it decreases the amount of moisture which can assist increase product shelf life and improve

product stability the enhancement in quality might be attributed to the conservation of taste and nutritional content.High temperatures can cause the breakdown or deactivation of enzymes in juice, which can improve shelf life however, it is vital to remember that high temperatures might create undesired colour changes, thereby harming the final product's visual attractiveness.If exposed to high temperatures, fats can oxidize,it can cause rancidity and a reduction in product qualityhigher temperatures can hasten fat oxidation in oil. The pH level of the feed solutions can have an effect on particular minerals such as calciumspray drying causes the removing of antioxidants through fibres. When the doughnut batter contains fibre-rich components, this effect may be real antioxidants can help to maintain the freshness and quality of baked foodstaste is severely suppressed at high temperatures.High temperatures can cause caramelization, while the hygroscopic qualities of sugar can cause stickiness.

FUTURE TRENDS:

The United Nations Food and Agricultural Organization has frequently said that agricultural production must grow in order to satisfy the estimated increase in food demand when the world population approaches 9.7 billion by 2050. To design sustainable future food systems, a detailed grasp of elements such as local economic disparities, global dietary patterns, growing per capita consumption and industrialization is required this should occur considering growing climatic risk arising from global warming and the resulting increases in climatic unpredictabilityGlobal per capita food consumption is expected to rise by 210 calories per day between 2015 and 2050 (7).Plant-based and alternative forms of protein are in high demand, and this trend is anticipated to continue food manufacturers will use innovation to produce plant-based goods that resemble the flavour and texture of conventional dairy and meat products personalized nutrition recommendations will be possible because the technological advancements like AI and data analysis. Products can be created by food processors that are specific to a person's dietary requirements and preferences as opposed to traditional spray drying the application of practical methodologies to spray drying enhanced product quality, including superior microstructural characteristics, short particle size dispersion and greater retention of bioactive chemicals Spray-dried blueberry powders generated using ultrasonic aided spray drying (atomizer, ultrasonic nozzle) demonstrated higher retention of total phenolic components and antioxidant activity (52). For the preservation of delicate items freeze drying is frequently utilized improved freeze-drying methods, such as the use of ultrasound or the incorporation of nanomaterials to accelerate drying speeds, may be a future trend. since lower temperatures plasma sterilization technology is a novel type of sterilization technology, its application in the food business is still in its infancy, hence its sterilization mechanism cannot be precisely stated at this time. It is commonly considered that the bactericidal

impact of plasma is connected to the charged elements (electrons, ions), active substances (molecules, stimulated atoms, metastable atoms, free radicals) and UV rays low temperature plasma may successfully reduce the cooking time of the grain and enhance the quality of the grain after cooking in addition to changing the surface of the starch (67).

Conclusion:

Food processing is the collection of technologies used to convert raw resources into edible itemsin order to respond to customer demand for healthier food options, a full investigation on the effects in the processing of food is necessaryit is critical for ensuring food accessibility, safety and varietyMcDonald's and the growth of processed snack items became symbols of this ageclearly the use of fire rendered raw meat and carrion palatable, safe, and tasty. while particular processing techniques have an influence on nutritional content, the whole dietary context must be considered. Processed foods frequently make up a sizable component of today's diets, and the long-term consequences of nutrient alterations in these items can have an impact on overall nutritional statusto optimize the nutritional advantages of processed foods, a balance of food security, accessibility, and nutrient retention must be achieved. customer education, government requirements and industry innovation all play a vital part in making sure processed food products continue to deliver key nutrients while also fulfilling customer preferences and needs for convenience and flavour. Understanding the impacts of processing foods on nutrients, in the end, provides for more educated dietary choices and better public health outcomespublic education, administrative guidelines, and commercial innovation all play important roles in striking this balance. Finally, knowing the impacts of the processing of food on nutrients allows people to make more educated dietary choices and emphasizes the necessity of improving the safety of food and retention of nutrients in today's food supply for progress to be made the field of food studies and development, global adaption of essential research and agenda development are necessary.

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