Extrinsic factors:

Is important in microbial growth in a food include the environmental conditions in which it is stored, which include:

-Temperature of storage.

- Relative humidity of environment.

- Presence and concentration of gases

- Presence and activities of other microorganisms.

The relative humidity and gaseous condition of storage, respectively, influence the a_w and Eh of the food**.**

Temperature of Storage:

Microorganisms important in foods are divided into three groups on the basis of their temperature of growth, each group having an optimum temperature and a temperature range of growth to : psychrotroph, mesophiles &thermophile. In food microbiology mesophilic and psychrotrophic organisms are generally of greatest importance. This is of paramount importance in food safety, because if you know the temperature growth ranges for dangerous microorganisms it helps you to select the proper temperature for food storage to make them less able to grow and reproduce.

Minimum growth temp. : lowest temp. at which spp. will grow.
Optimum growth temp. : Is temp. at which spp. grow best .
Maximum growth temp. : Highest temp. at which growth is possible

Psychrophiles : grow best at low temperatures (15–20°C); Sensitive to temperatures over 20^oC. Optimum growth at 15^oC or below.
The **psychrotrophs** found most commonly on foods are those that belong to the genera *Pseudomonas , Enterococcus ,Listeria monocytogenes and Yersinia.* These organisms grow well at refrigerator temperatures and cause spoilage of meats, fish, poultry, eggs, and other foods normally held at this temperature. Some organisms can grow over a range from 0^0C and 30^0C or above. One such organism is *Enterococcus faecalis*.

Mesophiles - grow best at 25–40°C; with temperature optima around 37 ^{0}C, are frequently of human or animal origin and include many of the more common food-borne pathogens such as *Salmonella, Staphylococcus aureus and Clostridium perfringens*. As a rule mesophiles grow more quickly at their optima than psychrotrophs and so spoilage of perishable products stored in the mesophilic growth range is more rapid than spoilage under chill conditions.

Whereas those that grow well at and above 45 ^{0}C with optima between 55°C and 65°C are referred to as **thermophile.** Most thermophilic bacteria of importance in foods belong to the genera *Bacillus* and *Clostridium.* Although only a few species of these genera are thermophilic, they are of great interest to the food microbiologist and food technologist in the canning industry.

Just as molds are able to grow over wider ranges of pH, osmotic pressure, and nutrient content, they are also able to grow over wide ranges of temperature as do bacteria. Many molds are able to grow at refrigerator temperatures, notably some strains of *Aspergillus, Cladosporium,* and *Thamnidium,* which may be found growing on eggs, sides of beef, and fruits. Yeasts grow over the psychrotrophic and mesophilic temperature ranges but generally not within the thermophilic range.

Relative humidity (RH):

The relative humidity of the storage environment is important both from the standpoint of a_w within foods and the growth of microorganisms at the surfaces. When the a_w of a food is set at 0.60, it is important that this food be stored under conditions of RH that do not allow the food to pick up moisture from the air and thereby increase its own surface and subsurface a_w to a point where microbial growth can occur. When foods with low a_w values are placed in environments of high RH, the foods pick up moisture until equilibrium has been established.

Foods that undergo surface spoilage from moulds, yeasts and certain bacteria should be stored under condition of low R.H. Improperly rapped meats such as whole chickens and beef cuts tend to suffer much spoilage in the refrigerator before deep spoilage occurs. This is due to high R.H of the refrigerator and the fact that meat spoilage microorganisms are aerobic in nature.

The general effect of lowering a_w below optimum is to increase the length of the lag phase of growth and to decrease the growth rate and size of final population. This effect may be expected to result from adverse influences of lowered water

on all metabolic activities because all chemical reactions of cells require an aqueous environment.

a_w is influenced by other environmental parameters such as pH, temperature of growth, and Eh. The minimum a_w was raised, however, when the incubation temperature was decreased. When both the pH and temperature of incubation were made unfavorable, the minimum a_w for growth was higher.

Presence and Concentration of Gases in the Environment:

Gases inhibit microorganisms by two mechanisms:

***1- Direct toxic effect*:** that can inhibit growth and proliferation. Carbon dioxide (CO_2), ozone (O_3), and oxygen (O_2), dependent upon the chemical and physical properties of the gas and its interaction with the aqueous and lipid phases of the food.

- *Carbon dioxide (CO2)* is the single most important atmospheric gas that is used to control microorganisms in foods. The inhibitory effect of carbon dioxide (CO2) on microbial growth is applied in *modified-atmosphere packing* of food.

- *Ozone (O3)* is the other atmospheric gas that has *antimicrobial properties*, it has been shown to be effective against a variety of microorganisms, but because it is a strong oxidizing agent, it should not be used on high-lipid-content foods since it would cause an increase in rancidity.

2- Second inhibitory mechanism is achieved by modifying the gas composition, which has ***indirect inhibitory effects*** by altering the ecology of the microbial environment. When the atmosphere is altered, the competitive environment is also altered. Atmospheres that have a negative effect on the growth of one particular microorganism may promote the growth of another. Nitrogen replacement of oxygen is an example of this indirect antimicrobial activity. It is typically used to displace oxygen in the food package either alone or in combination with CO_2, effect on aerobic microorganisms.

Presence and Activities of Other Microorganisms:

Some food-borne organisms produce substances that are either inhibitory or lethal to others; these include antibiotics, bacteriocins, hydrogen peroxide, and organic acids. General ***microbial interference*** is a phenomenon refers to the general nonspecific inhibition or destruction of one microorganism by other members of the same habitat or environment. The mechanisms of general

microbial interference are not as clear. Among the explanations for interference are:

(1) Competition for nutrients.
(2) Competition for attachment/adhesion sites.
(3) Unfavorable alteration of the environment.
(4) and combinations of these.

Sources of Microorganisms in Foods:

Microorganisms get into foods from both natural (including internal) sources and from external sources to which a food comes into contact from the time of production until the time of consumption. Natural sources for foods of plant origin include the surfaces of fruits, vegetables, and grains, the damaged tissues and the pores in some tubers (e.g., radish and onion). Natural sources for foods of animal origin include skin, hair, feathers, gastrointestinal tract, urogenital tract, respiratory tract, and milk ducts (teat canal) in udders of milk animals,
Besides natural microorganisms, a food can be contaminated with different types of microorganisms coming from outside sources such as air, soil, sewage, water, feeds, humans, food ingredients, equipment, packages, and insects. Microbial types and their levels from these sources getting into foods vary widely and depend on the degree of sanitation used during the handling of foods
The most common ways in which microorganisms enter food product are:

***Soil:**
Many types of moIds, yeasts, and bacterial genera (e.g., *Enterobacter, Pseudomonas, Proteus, Micrococcus, Enterococcus, Bacillus,* and *Clostridium)* can enter foods from the soil. Soil contaminated with fecal materials can be the source of enteric pathogenic bacteria and viruses in food. Removal of soil (and sediments) by washing and avoiding soil contamination can reduce microorganisms in foods from this source.

Water:
May contain various types of microorganisms; Contamination of foods with pathogenic bacteria, viruses, and parasites from water has been recorded. It is used for washing foods, processing (pasteurization, canning, and cooling of heated foods) and storage of foods (e.g., fish on ice), washing and sanitation of equipment, processing and transportation facilities. Although potable water does not contain coli-forms and pathogens (mainly enteric types), it can contain other bacteria capable of causing food spoilage, such as *Pseudomonas* and

Flavobacterium. Improperly treated water can contain pathogenic and spoilage microorganisms.

Utensils and equipments:
Do not have own microflora, main cause of ***cross contaminations*** (M.O present in raw foods, utensils and contaminated surfaces are transferred to prepared or washed foods or to clean surfaces) .
Raw eggs (which like uncooked poultry are a source of the *Salmonella*) are another common cause of cross contamination. Preventing cross contamination requires good food safety habits such as frequent washing of hands, utensils, cutting boards and work surfaces. Many types of microorganisms from air, raw foods, water, and personnel can get into the equipment and contaminate foods: *Salmonella, Listeria, Escherichia, Enterococcus, Micrococcus, Pseudomonas, Lactobacillus, Clostridia, Bacillus* spp., yeasts and moIds can get in food from equipment. Proper cleaning and sanitation of equipment at prescribed intervals are important to reduce microbial levels in food.

Air:
Non favourable environment for microbial growth; Excellent conveyer of microorganisms from other sources: sneezing, coughing, agricultural activities.Spores of *Bacillus* spp., *Clostridium* spp.; and molds, and some Gram-positive bacteria (e.g., *Micrococcus* spp. and *Sarcina* spp.), as well as yeasts, can be predominantly present in air. If the surroundings contain a source of pathogens (e.g., animal and poultry farms or a sewage-treatment plant), different types of bacteria, including pathogens and viruses (including bacteriophage), can be transmitted via the air. Microbial contamination of food from the air can be reduced by removing the potential sources, controlling dust particles in the air (using filtered air), using positive air pressure, reducing humidity level, and installing UV light.

Handlers:
They include not only people working in farms and food-processing plants, but also those handling foods at restaurants, catering services, retail stores, and at home. Human carriers have been the source of pathogenic microorganisms in foods that later caused food-borne diseases, especially with ready-to-eat foods. Improperly cleaned hands, lack of aesthetic sense and personal hygiene, and dirty clothes and hair can be major sources of microbial contamination in foods. The presence of minor cuts and infection in hands and face and mild generalized diseases (e.g., flu, strep throat or hepatitis A in an early stage) can amplify the situation.

In addition to spoilage bacteria, pathogens such as *S. aureus, Salmonella, Shigella* spp., pathogenic *E.coli,* Norovirus, and hepatitis A can be introduced into foods from human sources sometimes through fecal-oral contamination.

Plants (fruits & vegetables):

Some plants produce natural antimicrobial metabolites that can limit the presence of microorganisms. Fruits and vegetables harbor microorganisms on the surface. MoIds, yeasts, lactic acid bacteria, and bacteria from genera *Pseudomonas, Micrococcus, Erwinia, Bacillus, Clostridium.* and *Enterobacter* can be expected from this source.

Pathogens, especially of enteric types *(Salmonella, Escherichia coli, Campylobacter, Shigella, Cyclospora, Giardia),* can be present if the soil is contaminated with untreated sewage. Diseases of the plants, damage of the surface and improper storage conditions following processing can greatly increase microbial numbers.

Animals, birds, fish and shellfish:

Food animals and birds normally carry many types of indigenous microorganisms in the digestive, respiratory, and urogenital tracts, the teat canal in the udder, as well as in the skin, hooves, hair, and feathers.

Many as carriers, can harbor pathogens such as *Salmonella* serovars. pathogenic *Escherichia coli, Campylobacter jejuni. Yersinia enterocolitica,* and *Listeria monocytogenes* without showing symptoms.

Many spoilage and pathogenic microorganisms can get into foods of animal origin (milk. egg, meat, and fishery products) during production and processing. Milk can be contaminated with fecal materials on the udder surface; egg shells with fecal material during laying; meat with the intestinal contents during slaughtering, and fish with intestinal contents during processing.

In addition to enteric pathogens from fecal materials, meat from food animals and birds can be contaminated with several spoilage and pathogenic microorganisms from skin, hair, and feathers, namely *Staphylococcus aureus, Micrococcus* spp., *Propionibacterium* spp., *Corynebacterium* spp., and molds and yeasts