Technology applied to fresh-cut fruits and vegetables and its influence on the use of packaging material

Tecnología aplicada en las frutas y hortalizas de cuarta gama y su influencia en el uso del material de empaque

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Abstract: The preservation methods most commonly used to date to maintain the quality of fresh-cut vegetable products are low temperatures and modified atmosphere packaging, which maintains their sensory, nutritional and microbial quality for a longer period of time. In Ecuador, there are about 25 pre-prepared convenience food products marketed, 60% of which are mixtures for soups and salads, both fruit and vegetable. The cost of these products is higher than whole products and they are marketed mainly in urban areas, in supermarkets, hotels and catering services, they proposed a food program called "five a day" (five types of fruits and/or vegetables a day). This work aims to specify the different technologies applicable to fourth range products, to specify the type of packaging materials used for fourth range products and to explain the microorganisms that affect minimally processed products and finally to detail the advantages and disadvantages of fourth range products. The technologies applied to fruits and vegetables are used before they are pre-packaged; contaminated materials grow in an intrinsic and extrinsic environment. The advantages are that it extends its shelf life having a durability of up to 400% and its disadvantages is to control temperatures during storage, it does not allow the acceptance to consumers due to the action of irradiation, physical and chemical changes that are generated during the treatment of food.

Keywords: fresh-cut, fruit, packaging material, shelf life, advantages and disadvantages, cuarta gama, frutas, material de empaque, vida útil, ventajas y desventajas.

Resumen: Los métodos de conservación más utilizados hasta la actualidad para el mantenimiento de la calidad de productos vegetales de IV gama son las bajas temperaturas y el envasado en atmosfera modificada manteniendo su calidad sensorial, nutricional y microbiana durante más tiempo. En Ecuador se comercializan alrededor de 25 productos de cuarta gama, el 60% son mezclas para sopas y ensaladas tanto de frutas como de vegetales. El costo de estos productos es mayor que los enteros y se comercializan principalmente en la zona urbana, en supermercados además de hoteles y servicios de catering, propusieron un programa alimentario llamado "cinco al día" (cinco tipos de frutas y/o hortalizas al día. Este trabajo tiene como objetivo especificar las diferentes tecnologías aplicables a los productos de cuarto nivel, especificar el tipo de materiales de envasado que se utilizan para los productos de cuarto nivel y explicar los microorganismos que afectan a los productos mínimamente procesados y por último objetivo es detallar las ventajas y desventajas de los productos de cuarta gama. Las tecnologías aplicadas a las frutas y vegetales son utilizadas antes de ser previamente envasados; Los materiales contaminados crecen en un ambiente intrínsecos y extrínsecos. Las ventajas es que alarga su vida útil teniendo una durabilidad de hasta 400% y sus desventajas es controlar las temperaturas durante el almacenamiento, no se permite la aceptación hacia los consumidores debido a la acción de las irradiaciones, cambios físicos químicos que se genera durante el tratamiento del alimento.

Introduction

In recent years, people have paid increasing attention to eating fresh foods that can maintain sensory, nutritional and microbial quality for longer. One option to solve this problem is to minimize the processing of vegetables and fruits, also known as the fourth series of products (series IV), which are characterized by only washing, cutting and packaging treatments without heat treatment or other more complicated processes. Its main advantage is that it can be consumed immediately.

The most marketed IV-range products are: ready-to-eat salads, cut vegetables ready to be incorporated into meals, fruit mix as a snack, among others, having a large presence in supermarkets due to the growing demand of consumers for ready-to-serve products. (Moreno-Miranda et al., 2020).

In addition to the technological advances being made in the fresh-cut sector to reduce the risks of contamination, these fruits and vegetables have been identified and implicated in some problems related to public health.

Fresh-cut products are becoming more and more important in our country, due to the increase in the consumption of fruits and vegetables, which are key in the daily diet.

One of the most frequent and widely used preservation techniques that currently allows us to maintain the quality of fresh-cut vegetable products are low temperatures and products packaged in modified atmosphere (MAP). On the other hand, there is an application of new technologies that are able to preserve the organoleptic quality and inhibit the development of microbial flora before, during and after processing, as well as the necessary distribution.

Unlike fresh products on the market, the disadvantage of Series IV products is that due to their high perishability, shelf life is even shorter. Technologies to reduce the spoilage of such products range from the application of different chemical preservatives to the use of emerging technologies (such as radiation or smart packaging).

Although the series of fresh-cut products can solve problems such as changes in the diet of consumers caused by the rhythm of life, these products also have disadvantages because they are exposed to microbial risks, the sterilization/

pasteurization system that eliminates the initial microbial load may even increase during processing.

In Ecuador, about 25 convenience food products are marketed, 60% of which are mixtures for soups and salads, both fruit and vegetable. The cost of these products is higher than whole products and they are marketed mainly in urban areas, in supermarkets, hotels and catering services.

The OMS (2015) proposed a food program called "five a day" (five types of fruits and/or vegetables a day), with the objective of promoting the consumption of fresh vegetable products, with which the daily needs of vitamins and minerals that the human body requires are satisfied, thereby reducing health risk factors and creating an important change in the eating habits of the population. In fruit production, farms are large (areas larger than 100 ha), but with a lower degree of diversification of products; they have more efficient coordination mechanisms in the logistics of harvesting, grading and other procedures demanded by domestic and foreign markets. (Moreno-Miranda et al., 2020).

Through the investigation of fourth range products, it can be appreciated that the presence of browning in the fruit will cause economic losses, product quality and reference value for the consumer, due to the fact that it is a fast consumption product, its appearance and quality are fundamental. Enzymatic browning in fresh-cut products is very important, because this type of product can cause losses, since the cuts in the fruit will cause the oxidation of phenological compounds by the action of enzymes.

The cutting process makes vegetables more susceptible to chemical and microbial damage, because in the process, cells are destroyed and secretions rich in minerals, sugars, vitamins and other compounds are released. These nutrients allow microorganisms to grow. Extending the shelf life of minimally processed vegetables packaged in a modified atmosphere limits the growth of certain microorganisms. However, this technology can create suitable conditions for the slow growth of pathogenic bacteria.

Antioxidants are natural substances that play a very important role in the prevention of cellular damage, they are responsible for protecting the formation of free radicals, cellular oxidation originates from these free radicals related to physiological aging (Gil et al., 2016).

The production of fresh-cut convenience food products uses different techniques to avoid this problem, including physical and chemical ones. In this way, their shelf life can be extended, which, together with the increased demand for such products, can be a good opportunity for the company (Moreno-Miranda et al., 2020).

The technologies applied in the production of IV-range foods are products within which shelf life will depend on many factors, among them: the quality of raw materials, the technology used in their production, the incidence rate and the interaction with sources of microbial contamination. On the other hand, even if the shelf life of series IV products is up to 21 days, other non-microbial degradations will occur, such as ethylene production, respiration, formation of volatile and non-volatile compounds and enzymatic and non-enzymatic browning.

To solve this problem, there are currently a variety of methods to reduce the microbial load and increase the shelf life of fresh-cut products. (Gil et al., 2016).

One of the advantages and disadvantages of fourth range products when applying technologies are in terms of physical methods, their major advantage is that they can extend the shelf life of food by up to 400%, maintain the sensory quality of the product, are chemically and thermally stable methods and have no toxic residues. Series IV products are freshly packaged products that can maintain their nutritional properties.

Increased shelf life of foods because this system delays and/or prevents microbial growth and chemical and enzymatic deterioration. This increase in shelf life is very interesting for fresh and minimally processed products that present a very limited shelf life without protective atmosphere packaging (Hernández et al., 2014). The need to design an atmosphere suited to the characteristics of the food, selecting the most appropriate gas or gases at the most effective concentration.

For this, the chemical composition of the product, the main reactions involved in its deterioration during storage, the microflora present, its pH, its water activity, etc., must be known. The high initial investment in packaging machinery and control systems to detect perforations in the containers, the amount of residual oxygen and variations in the gaseous composition of the atmosphere created. The cost of packaging materials and gases used (except in vacuum packaging). The increase in the volume of the packages (except in vacuum packaging) which means an increase in the space required for storage, transport and display. (Hernández et al., 2014).

Intrinsic factors:

pH: De La Cruz y Roncal (2014) express that it is one of the factors that affect food at the time of storage, since most bacteria grow with a neutral to alkaline pH, when the product has a pH of 7 or higher it is vulnerable to bacterial growth, but in foods with a pH of 4.5 there is no growth of pathogenic bacteria, however, they are more susceptible to damage by filamentous fungi or yeasts. Food could be preserved in adequate microbiological conditions with a pH of less than 4.0, for fruits and vegetables there are methods that seek to control the pH through the endogenous production of organic acids such as acetic, citric and even lactic acid can be used. Jurado y Pacheco (2019) The authors explain that fourth range vegetables such as tomatoes and carrots correspond to the group of foods with low acidity, with a pH value between 5.8 and 6.0, accompanied with high humidity and surface cuts, present ideal conditions that produce microbial proliferation.

Water Activity (

) Jurado and Pacheco (2019) describe water activity as the ratio of the vapor pressure of a food to the vapor pressure of pure water, in other words, water activity is the measure of the force that decreases movement, a measure of the degree to which microorganisms use the water in the product. The scale of Aw is from 0 to 1, foods with a level close to 0.2 are very dry; very fresh foods have a value close to 0.99 of water activity, in this case microorganisms can proliferate with a value of 0.98 of water activity thus affecting the food.

Carrillo y Reyes (2013) argue that the water activity in vegetables is less than 0.98, in this group is included carrot and tomato, which are in the range of potentially hazardous foods, being more prone to the growth of pathogenic microorganisms, they mention that to reduce the water activity can be decreased with the addition of salt, sugar or other substances, another method to reduce this value is the evaporation of water. Sánchez y Cheyene (2014) The water activity can be reduced by the addition of salt, sugar or other substances, another method to reduce this value is the evaporation of water (dehydration) and by freezing.

Extrinsic factors:

Temperature: Bastidas, (2016) indicates that minimally processed horticultural products should be stored at an optimum temperature between 0 and 5 ºC, which preserves the quality and increases the shelf life of the product, in addition, low temperatures also delay microbial growth and reduce respiration, since respiration is higher in this type of food compared to whole products, it should be taken into account that temperature is an important factor to preserve quality and reduce post-harvest orders.

Argerich et al., (2016) mention that the temperature for cold storage of tomato varies between 7 to 15 ºC, but this will also depend on the degree of maturity that it presents, it is a decisive factor to select the optimum storage temperature, it is suggested that the ripe green tomato is preserved at a temperature between 12.5 and 15 ºC, if stored at lower temperatures may suffer damage from cold; the light red should be kept between 10 and 12.5 ºC, the firm ripe tomato can be stored between 5 and 7ºC, if stored at low temperatures of -1ºC causes freezing damage, in products of watery, translucent and very soft pulp, at high temperatures of 30ºC the product will develop an irregular ripening, discoloring the skin of the fruit.

Yucra y Zapana (2009) indicate that storage temperatures of 3 to 5 ºC mature carrots are preserved with a minimum development of rotting, immature carrots can be stored between 3 to 5 ºC without seeing any development of rotting, sprouting and dehydration, On the other hand, tied carrots are perishable due to the fact that they have stems; they can maintain their quality for 8 to 12 days in frozen storage. In the case of this research, carrots with minimal processing (fresh, cut and peeled) maintain their quality at temperatures between 3 to 5 ºC, the same as unripe carrots.

Relative Humidity: The Pan American Health Organization (PAHO) and the World Health Organization (WHO) explain that the optimum storage temperature is related to the humidity found on the outside of the food, i.e. in the environment. (2015) explain that the optimum storage temperature is related to the humidity found in the external part of the food, i.e. in the environment, and the relative humidity influences the water activity of the product, in effect the food having low water activity should be kept in an atmosphere with high relative humidity, where the water activity will increase causing deterioration due to the growth of microorganisms. "Generally, the higher the storage temperature, the lower the relative humidity, and vice versa. An alternative is to alter the gases in the atmosphere so that it is possible to delay microbial multiplication in the food without lowering the relative humidity."

Fernández y Martínez (2016) explain that according to the humidity of the cold storage room where the horticultural products are stored, the gradient with respect to the humidity of the product can be higher or lower, thus affecting the transpiration of the products consequent to the loss of turgidity and desiccation. The temperature and humidity of vegetables for storage is 2 ºC with 95% relative humidity. It is important to keep in mind that humidity favors the growth of molds and yeasts if there is no adequate air circulation. Rodríguez (2013) In carrots the optimum relative humidity for storage is 98 to 100%, and 90 to 95% humidity in tomatoes.

FIGURE 1

Controlled Atmosphere Storage of Fruits and Vegetables

Akribis. Info, 2020

Materials and methods

There is a wide variety of methods to reduce the microbial load and increase the shelf life of IV-range products. These can be classified into chemical and physical methods, which are mentioned below: - Chemical methods: chlorine (hypochlorite), chlorine dioxide, acidified sodium chlorite, bromine, iodine, trisodium phosphate, quaternary ammonium compounds, organic acids (lactic, citric, acetic, tartaric and ascorbic acids), hydrogen peroxide, peroxyacetic acid, calcium solutions, ozone and electrolyzed water. (Matiacevich et al., 2016).

Some materials applied in the technology are sanitizers such as:

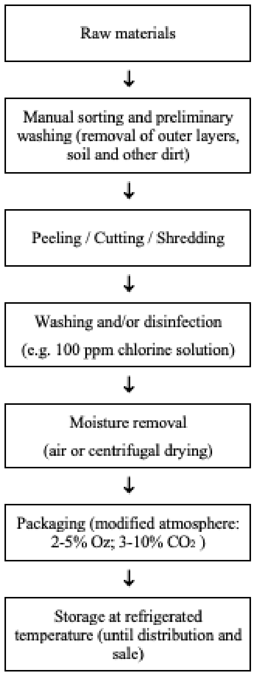
§ lactic acid, sodium hypochlorite, sodium chlorite, chlorine dioxide, ozone in water, UV-C

Films are also used to protect the food from the environment, but also, they are able to control the transfer of moisture, oxygen, carbon dioxide, flavors and aromas, reduce the growth of fungi and bacteria, improve appearance and provide structural integrity.Edible films, as reported by Matiacevich et al (2016) edible films have been classified according to the structural material from which they are made, so that there are edible films based on hydrocolloids (proteins and polysaccharides), lipids and the mixture of hydrocolloids and lipids, called composite films (composites). For packaging, materials such as flexible bags, plastic bags, trays and tubs can be used to avoid moisture losses and thus prevent loss of vitamins and minerals from the packaged products. (Matiacevich et al., 2016).

Figure 2. Flow diagram of the production flow chart for fresh-cut products

FIGURE 2

Flow diagram of the production flow chart for fresh-cut products



IV-range products Oliveira et al., 2015., Elaborado por: Autor

Types of packaging material used in fresh-cut products

Modified atmosphere packaging is a key determinant of shelf life. Numerous studies have been carried out with different plastic materials, with the determining factors being the permeability of the materials and the thickness of each plastic film.

FIGURE 3

Technology applied in fresh-cut products Magazine and Publications Santiago de Chile, 2016

Magazine and Publications Santiago de Chile, 2016

Bioriented polypropylene

Polypropylene is a polymer composed of thousands of biologically oriented linear units, which can significantly improve the optical, mechanical and water vapor barrier properties of the film. BOPP has become the most widely used film in the flexible packaging industry due to its excellent water vapor barrier. The packaging of cookies, snacks and all basic food ingredients must not lose or absorb moisture. Its main characteristics are high transparency and gloss, excellent water vapor permeability, wide range of thicknesses, different sealing temperatures, good cost/performance ratio and great versatility.

Low density polyethylene

It is a polymer with a highly branched chain structure. This makes it has a lower density, which is characterized by good heat resistance and chemical resistance, good impact resistance, milky white color, can become transparent according to its thickness, and can be used in thermoplastics, such as injection. And squeeze and be softer (Matiacevich et al., 2016).

Sealable polypropylene

Oppp's non-oriented coextruded films are designed to provide high sealability and achieve the best balance of transparency, stiffness, slip resistance and tear resistance. Its formulation produces excellent moisture resistance. All types of packaging, whether plastic bags, trays or tubs, can prevent water loss, thus avoiding the loss of vitamins and minerals in packaged products.

The less processed product will form a barrier to isolate the product from external contaminants. It can also maintain relative humidity in the container, extend the volume of processed vegetables and fruits, and help maintain product freshness.

Vegetables consist mainly of water, resulting in high water activity (> 0.99). Intracellular pH is another important intrinsic factor and varies for most minimally processed vegetables from 4.9 to 6.5. The wounded areas of the vegetable tissue provide a better substrate for microbiological growth by providing nutrients and the properties of the tissue determine which microorganisms will be active and allow their growth as soon as nutrients are available. Therefore, the preparation of fresh-cut products can lead to a number of consequences that imply an increased risk of microbial contamination. (Matiacevich et al., 2016).

The control of microorganisms in these products, which do not undergo any heat treatment, can only be achieved by very strict sanitization during the processing stages and adequate preservation in modified atmosphere under refrigerated conditions. Furthermore, it must be borne in mind that sanitization treatments must not compromise the organoleptic quality of the product. (Moreno-Miranda et al., 2020).

In general, the total mesophilic count in minimally processed vegetables immediately after packaging or bagging is between 103 to 106 colony forming units (CFU)/g. However, when these bags arrive at supermarkets, caterers or any point of sale, this count is found between 103 to 109 CFU/g. The species that make up this group are very heterogeneous and include all bacteria, molds and yeasts that grow under aerobic conditions. Therefore, the determination of aerobic mesophilic microorganisms (AEM) indicates the sanitary conditions of the food during the handling stage.

Among the microbiological alterations of fresh-cut products, bacteria are mainly responsible for the degradation of refrigerated vegetables more frequently than other microorganisms and most of the bacteria responsible for the alteration of vegetables are Gram-negative and of these, Erwinia is among the most aggressive.

The dominant bacterial population during low-temperature storage consists mainly of species belonging to the Pseudomonadaceae (especially P. fluorescens) and Enterobacteriaceae (especially Erwinia herbicola and Rahnella aquatilis), plus some species belonging to the lactic acid bacteria (especially Leuconostoc mesenteroides). In addition to Gram-negative bacteria, other Gram-positive bacteria, especially clostridia and bacilli can also cause alterations, but refrigeration temperatures slow down their growth.

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Chemical methods: chlorine (hypochlorite), chlorine dioxide, acidified sodium chlorite, bromine, iodine, trisodium phosphate, quaternary ammonium compounds, organic acids (lactic, citric, acetic, tartaric and ascorbic acids), hydrogen peroxide, peroxyacetic acid, calcium solutions, ozone and electrolyzed water.

Chemical methods have advantages such as: low cost, there may be synergisms between the compounds used, high penetration capacity and, in general, high antimicrobial activity. However, they also have disadvantages, such as the fact that many are corrosive compounds, their activity depends on the pH, and they require monitoring due to the toxic volatiles that may be emanated during their use, among others.

Physical methods: modified atmosphere packaging, active and intelligent packaging, nano-composite packaging, edible films and coatings, irradiation, ultraviolet light, pulsed light, high pressure processing, ultrasound and cold plasma. In the case of physical methods, the main advantages are that they increase the shelf life of food by up to 400%, maintain the sensory quality of the products, are chemically and thermally stable, and are free of toxic residues; while, among their disadvantages are the need to control the storage temperature of the products, consumer acceptance due to the perception of processes such as irradiation, difficult scaling, and the possibility of physicochemical changes in the food, among others.

Edible films and coatings

It is defined as a prefabricated edible film or thin layer of edible materials. Once formed, it can be placed over or between different food ingredients. The difference with film is the edible coating.

Edible films and coatings can not only protect food from environmental contamination, but also control the transfer of moisture, oxygen, carbon dioxide, essence and aroma, reduce the growth of fungi and bacteria, and improve food nutrition. Appearance and structural integrity; in addition, they can obtain different functional properties depending on the properties of their constituent materials. These latter characteristics are influenced by different factors, such as the type of material used (conformation, molecular mass, charge distribution), conditions under which these edible films are prepared (type of solvent, pH, concentration, temperature, etc.), and the type and concentration of additives used in their preparation (plasticizing agents, crosslinking, emulsifiers, antimicrobials and antioxidants, etc.). (Gil et al., 2016).

Currently, the use of polymers of natural origin for the elaboration of edible films and coatings is being widely studied and have been applied to different foods, such as meat derivatives, cereals, nuts, fruits and vegetables. The use of edible films and coatings for food protection and preservation has many advantages over the use of synthetic materials, mainly because they are biodegradable and environmentally friendly, in addition to being considered "natural" and safe. According to Quintero, edible films have been classified according to the structural material from which they are made, so that there are edible films based on hydrocolloids (proteins and polysaccharides), lipids and the mixture of hydrocolloids and lipids, called composite films (composites). On the other hand, antimicrobial agents are components that can be incorporated into active packaging and/or edible films and coatings, where their antimicrobial effect is caused by the discharge of volatile substances into the upper space of the packaging or their migration from the packaging. caused. Food container material.

Currently, volatile antibacterial substances commonly used in the active packaging of products in the IV range are SO2, ClO2, ethanol, etc., which can be incorporated into packaging to control the growth of fungi and bacteria. SO2 is incorporated into the packaging material as metabisulfite, which is very effective against mold growth in fruits. It should be noted that metabisulfite is a compound that should be handled with certain precautions, because it can cause irritation, but it does not cause major hazards to consumers.

Other volatile compounds that have received attention for their antimicrobial properties are hexanal, 1-hexenol, methyl benzoate, 2-nonanone. The latter is a volatile compound found in the aroma of strawberries that exhibits fungistatic properties, which increases the shelf life of strawberries and apples. There are also non-volatile antimicrobial agents, such as weak organic acids (acetic, benzoic, sorbic, citric, propionic, etc.), enzymes (lysozyme, glucose oxidase), bacteriocins (nisin, pe-diocin), synthetic fungicides (ima-zalil), metals (silver, copper and zirconium), and natural plant extracts (thymol, carvacrol, eugenol, citral, etc.). (Matiacevich et al., 2016).

In the manufacture of fresh-cut products, the most commonly used antimicrobial agents are: a) Citric acid: Inhibits bacterial growth by chelating ions essential for their development. It can also be used to prevent enzymatic browning because it acts as a copper chelating agent (co-factor of polyphenol oxidase). Concentrations used range from 0.1 to 0.3% and for antioxidant action at levels of 100 to 200 ppm.

Result

Applied technologies

A study was carried out on the technologies applied to 4th range fruits and vegetables, where several methods are applied before being previously packaged;

methods that serve to extend the shelf life of the product; these methods can be physical or chemical, applying different treatments in each of them according to the requirements of the product, as well as the type of material used for these processes and the conditions under which the horticultural products must be conditioned.

Use of packaging materials for fourth range products

During packaging, a modified atmosphere was applied, for which several tests were carried out to check and determine which treatment would be considered one of the best; one of them was to apply the temperature, among the environmental factors, which is an essential parameter since it influences the speed of enzymatic reactions and the deterioration of the vegetables.

A packaging machinery and control systems allow detecting perforations in the packages, the amount of residual oxygen and variations in the gaseous composition of the atmosphere created. The cost of packaging materials and gases used (except for vacuum packaging). The increase in the volume of the packages (except in vacuum packaging) which means that there is an increase in the space required for storage, transportation and display according to (García et al., 2012).

Low density polyethylene materials is recommended because it has a highly branched chain structure i.e. it is of lower density, which is characterized by good heat resistance and chemical resistance, good impact resistance, milky white color, can become transparent depending on its thickness, and it manages to handle in thermoplastics, such as injection, it is pressed and becomes very soft (Matiacevich et al., 2016).

Conditions for microbial growth

It is very important to emphasize that microorganisms grow in a humid environment, in neutral alkaline pH and in contaminated materials, as well as pathogenic bacteria, fungi and yeasts can also grow depending on the type of food, especially in highly perishable products. It should be noted that there are intrinsic and extrinsic factors.

Table 1. *Study of Intrinsic Factors*

Table 1

Study of Intrinsic Factors

Ph	Factor	Products
7 or greater	Microbial growth	Any food
4.5	No pathogenic growth They are susceptible to filamentous fungi or yeasts.	Fruits and vegetables
4.0	Totally stable, no M.O.	Fruits and vegetables
5.8 – 6.0	Low acidity Ph High humidity Surface cutting Microbial proliferation	Tomatoes and carrots

De la Cruz and Roncal, 2014, Jurado and Pacheco, 2019, Prepared by: Author

Table 1 indicates the intrinsic factors and the damage they can cause, especially pathogenic bacteria, and this important factor is pH. The aforementioned authors make it clear that fourth range products also correspond to the group of foods with low acidity, with a pH value between 5.8 and 6.0, among other factors that could occur during handling. Bacteria are responsible for the degradation of refrigerated vegetables more frequently than other microorganisms and most of the bacteria responsible for vegetable spoilage are Gram-negative and of these, Erwinia is among the most aggressive.

Extrinsic factors include temperature, i.e., for every 10 °C increase, deterioration is faster and the rate of loss in nutritional quality will increase, presenting water loss and its organoleptic characteristics in the food according to Bastidas, 2016.

Table 2. *Study of Extrinsic Factors*

Table 2
Study of Extrinsic Factors

Temperature	Factor	Products
0 – 5°C	Preserves quality Increased useful life	Horticultural
7 – 15°C	Maturity level (1) Optimum temperature	Degree of maturity of tomato
12.5 – 15°C	Maturity level (2) Optimum temperature	Ripe green tomato
10 – 12.5°C	Optimum temperature (3)	Light red tomato
5 – 7°C	Optimum conservation	Firm ripe tomato
– 1°C	Freezing damage	Different degrees of tomato maturity
3 – 5°C	Minimal rotting condition	Ripe carrots
3 – 5°C	No rotting Sprouting and dehydration	Immature carrots or minimal processing carrots (fresh, cut and peeled)

Bastidas, 2016; Argerich, Troilo, and Rodriguez, 2016, Yucra and Zapana, 2009, Prepared: Author.

As can be seen in Table N° 2, the way to maintain the product is the temperature in such conditions, but there is also an important factor due to the degree of maturity of the vegetables according to scale, specifically in the extrinsic factors.

Another factor of great importance is the *water* activity .

. between the vapor pressure of a food and the vapor pressure of pure water, i.e. the measure of the force that decreases the movement, a measure of the degree of utilization of the product water by microorganisms where the water activity is from 0 to 1, foods with a level close to 0.2 are very dry; very fresh foods have a value close to 0.99 of water activity, in this case microorganisms can proliferate with a value of 0.98 of water activity, thus disturbing the food.

But in vegetables it is less than 0.98, including carrots and tomatoes, which are in the range of potentially hazardous foods, being more prone to the development of pathogenic microorganisms, Sanchez and Cheyene mention that to reduce water activity can be reduced with the addition of salt, sugar or other substances, another method for reducing this value is evaporation of water (dehydration) and by freezing. (2014) Sanchez and Cheyene mention that to reduce water activity can be reduced by adding salt, sugar or other substances, another method to reduce this value is evaporation of water (dehydration) and by freezing.

The Pan American Health Organization (PAHO) and the World Health Organization (WHO) (2015) expresses that the optimum storage temperature is related to the humidity found in the external part of the food i.e. in the environment, and the relative humidity influences the water activity of the product, in effect the food having low water activity should be kept in an atmosphere with high relative humidity, where the water activity will increase causing spoilage by the growth of microorganisms. "Generally, the higher the storage temperature, the lower the relative humidity, and vice versa.

Fernandez and Martinez (2016) explain that according to the humidity of the cold room where the vegetable products are stored, the gradient with respect to the fruit humidity can be higher or lower, thus affecting the transpiration of the products consequent to the loss of turgidity and desiccation. The temperature and humidity of vegetables for storage was 2 °C with 95% relative humidity. Therefore, this favors the growth of molds and yeasts if there is not adequate air circulation. Rodriguez (2013) indicates that for carrots the optimum relative humidity for storage was 98 to 100%, and 90 to 95% humidity specifically for tomatoes.

Advantages and disadvantages

Table 3. *Technological Application for Fourth Range Products. (Chemical form - lengthen shelf life)*

Table 3

Technological Application for Fourth Range Products Chemical form lengthen shelf life

Chemical Methods	Advantages Action and benefits	Disadvantages
Chlorine dioxide. Acidified sodium chlorite. Bromine. Iodine. Trisodium phosphate. Quaternary ammonium compounds. Organic acids. Hydrogen peroxide. Peroxyacetic acid. Calcium solutions. Ozone and electrolyzed water.	Microbial activity. High penetration capacity and low cost.	They are corrosive. Depends on pH. Monitoring for toxic volatiles

Moreno-Miranda et al., 2020. Prepared by: Author

Table 3 shows the advantages and disadvantages of the use of chemicals and the benefit that they act mainly against the microorganism, but they are duly controlled by their reactions; there may be disadvantages during their misuse in processing.

Table 4. *Technological Application for Fourth Range Products. (Physical Form - lengthen shelf life)*

Table 4

Technological Application for Fourth Range Products Physical Form lengthen shelf life

Chemical Methods	Advantages Action and benefits	Disadvantages
Modified atmosphere packaging Active and intelligent packaging. Packaging with edible nanocomposites, films and coatings Irradiation. Ultraviolet light. Pulsed light. Processing with high pressure ultrasound and cold plasma.	Increase service life up to 400%. Maintain the sensory quality of the products Absence of toxic residues.	Temperature control in product storage, consumer acceptance and perception of the irradiation process, difficult scaling, physicochemical changes in foodstuffs, etc.

Moreno-Miranda et al., 2020. Prepared by: Author

Table 4 shows that, advantageously, its useful life for food has a durability of up to 400%, i.e. it is recommended for use in food products and also helps the organoleptic characteristics, while its disadvantages are that it is necessary to control the temperature during storage of the products, it does not allow acceptance by consumers due to the action of irradiation and the physical chemical changes generated during the treatment of the food.

These two methods allow the decontamination of the food to be processed by this mechanism, which will reduce any infection, reduce spoilage by microorganisms, preserve the organoleptic characteristics and freshness of the food, help to maintain its nutritional characteristics, as well as the absence of unacceptable levels of toxic residues or the formation of toxic products.

According to (Hernández, 2013)The increase in shelf life of foods is because this system delays and/or prevents microbial growth and chemical and enzymatic deterioration. This increase in shelf life is very interesting for fresh and minimally processed products that present a very limited shelf life without protective atmosphere packaging.

(Gil et al., 2016)If the shelf life of series IV products is up to 21 days, other non-microbial degradations will occur, such as ethylene production, respiration, formation of volatile and non-volatile compounds, and enzymatic and non-enzymatic browning.

To solve this problem, a wide variety of methods are currently available to reduce the microbial load and increase the shelf life of fresh-cut products.

In research Moreno-Miranda et al., (2020)The control of microorganisms in these products, which do not undergo any heat treatment, can only be achieved through very strict sanitization during the processing stages and adequate preservation in a modified atmosphere under refrigerated conditions. In addition, it must be taken into account that sanitization treatments must not compromise the organoleptic quality of the product.

Conclusions

The study explained that the IV-range products are currently in good use of the applied method, since they have been declared as the food of the future since they maintain the freshness of fruits and vegetables, improving the convenience for consumers and encouraging the consumption of fruits and vegetables based on these processes in order to help people eat healthily and thus avoid diseases.

It is necessary that, when using the type of packaging material for fourth range and IV-range products, they are specifically designed to facilitate sealing and thus achieve a better balance of reliability, firmness to slipping and resistance to the type of material; and especially to humidity. The packaging, whether plastic bags, trays or tubs, can prevent water loss, thus avoiding the loss of vitamins and minerals in packaged foods.

They are also considered to maintain the relative humidity in the container, thus extending the volume of processed vegetables and fruits helping to maintain the freshness of the product.

Regarding the growth of microorganisms, it can be considered that the conditions of fresh-cut products are mainly composed of water, resulting in a high water activity (> 0.99). Intracellular pH is another important intrinsic factor and varies for most of these minimally processed products from 4.9 to 6.5. The bruised areas of the plant tissue facilitate a better substrate for microbiological growth by providing nutrients and the properties of the tissue check which microorganisms will be active and which allow the growth of these at the time nutrients are available resulting in a risk of microbiological contamination especially to these products passed through this minimally processed medium.

Finally, one of the advantages and disadvantages of fresh-cut products are the technologies applied to extend the shelf life of the product, but it will depend on many factors. It is also necessary to know that these products can last up to 21 days according to a study, after that time they tend to degrade, but not by microorganisms but by volatile substances and enzymatic and non-enzymatic browning.

The technologies applied in the production of fresh-cut foods are products whose shelf life will depend on many factors, among them: the quality of raw materials, the technology used in their production, the incidence rate and the interaction with sources of microbial contamination.

The disadvantage is during misuse in processing, as well as controlling the temperature during storage of the products, not allowing acceptance by consumers due to irradiation and physical and chemical changes during food processing.

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