CONDITIONING OF HORTICULTURAL PRODUCTS FOR CONSUMPTION IN FRESH STATE USING ULTRAVIOLET NON-IONIZING RADIATION, UV-C

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ABSTRACT

This paper presents the conditions and equipment underlying the work processes within the flow of conditioning technologies of horticultural products, in order to prolong the life and freshness of fruits, from the time of harvest and storage, to their marketing for consumption.

INTRODUCTION

Fruits and vegetables eaten fresh can be carriers of optional pathogenic microorganisms: *bacteria, yeasts, molds*. Rot of fruits and vegetables are caused mainly by fungi, which attack first the injured parts, in particular by insects. These microorganisms can cause either loss of horticultural products during storage, due to the decay process in post harvest, either disease or food poisoning with direct effects on the health of human consumer.

Losses of horticultural products, due to the decay process in post harvest, are of 10-50% depending on the degree of development of that area and temporary storage facilities.

Of particular importance in order to achieve acceptable longer times for storage in refrigerated state of products is to ensure both at the beginning and during chilling of small microbiological loads. This requires minimizing the possibility of microbiological contamination of products at all stages preceding actual refrigeration application and during this process.

Under these conditions, a conditioning technology of horticultural products for fresh consumption - fig. 1:

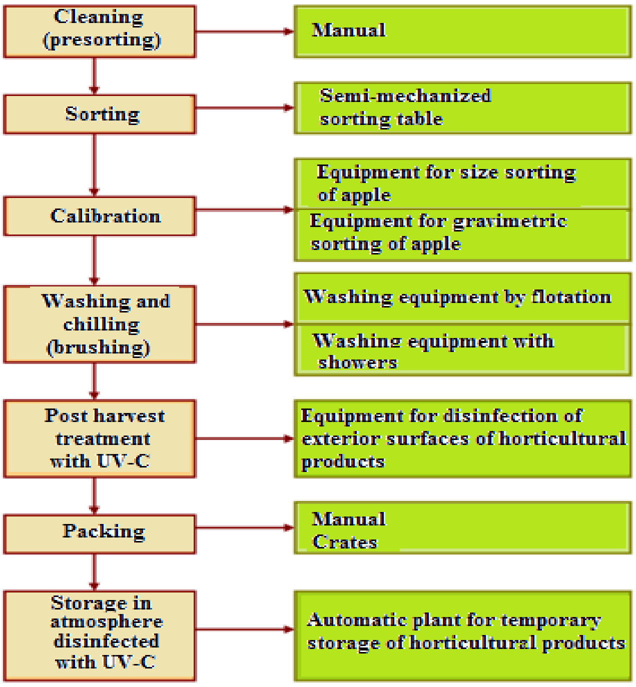

Fig. 1 *- Conditioning technology of horticultural products for fresh consumption*

MATERIAL AND METHOD

Conditioning technology of horticultural products for fresh consumption involves the following operation:

- ***Cleaning (presorting):*** aims to eliminate obviously poor quality products and various impurities (leaves, branches, etc.) of horticultural products mass. This operation is done by hand, with harvesting or emptying of picking containers and is of great importance if fruit for storage.
- ***Sorting:*** is the operation by which the fruits are grouped in relation to existing defects, degree of maturation, colour, etc., in various quality classes. It is achieved by choosing defective fruits from the mass of products subjected to sorting. Fruits pass in front of sorters on sorting tables or belts (fig. 2) which supply their rotation, allowing a careful examination throughout the entire surface. Movement speed is reduced to have time to remove inappropriate specimens.

***Fig. 2** – Sorting table RB* [22]

- ***Calibration***: is the operation by which horticultural products are grouped by their size according to the standard, national technical rules etc. Products calibrated are more visually appealing and can be packed easily allowing equalization of packaging in terms of their number. Depending on the means used, the calibration is done manually or mechanically. Mechanical calibration is frequently used and is performed either in relation to the diameter of the fruit, respectively their weight (fig. 3).

***Fig. 3** - Equipment for sorting apples by size (ECM) / gravimetric (EM)*

- ***Washing and chilling (brushing): complement of sorting and grading operations of some fruits, such as citrus, apples, peaches, etc., in order to remove any remaining substances on the surface of the fruit due to the application of chemical treatments in culture, adhesions of other type (dust), ensuring them a pleasant commercial aspect.***

Washing (fig. 4) is performed by immersing the fruit or by its exposure to fine jets. In the wash water can be added chemicals that forbid the attack of pathogens. Washing can be completed by brushing operation, which increases the effectiveness of washing. Brushing is sometimes applied without prior washing (eg. for peaches), removing quantities of chemicals, dust, etc., being lower in this case. Any washing operation should be followed by chilling with hot or cold air.

Fig. 4 – *Machine for fruit washing by splashing, Boema Mod. L4-L5* [23]

For brushing it can be used the BM brushing machine (fig. 5).

Fig. 5 – *Machine for fruit brushing BM* [22]

- ***Post harvest treatment with UV-C***: after washing and chilling, is performed the post harvest treatment with ultraviolet unionized radiation UV-C.
- ***Packing***: is done in order to keep the product in cold storage. Packing mode is selected depending on the product that needs to be stored. For a better distribution of cooling air one can choose packaging in wooden or plastic boxes in one of the schemes of arrangement: lax, compact, mixed and with ventilation duct.
- ***Storage in atmosphere decontaminated with UV-C***: after packing operation in the storage space, are settled the parameters of refrigeration operation in cold air, respectively the temperature and humidity inside.

RESULTS AND DISCUSSIONS

In the modern conservation methods, it has a great potential the use of non-ionizing ultraviolet radiation UV-C. Wavelength between 200 and 280 nm, which is considered lethal for most types of microorganisms, affects the replication of pathogen DNA [4, 5].

Non-ionizing UV radiation can cause breaks in chemical bonds and can induce molecular photochemical reactions. All nutrition and toxicological studies undertaken showed the absence of any harmful effects of ions, excited atoms and molecules generated during irradiation. DNA damage by irradiation of undesirable microorganisms found in food leads to their inactivation. The amount of energy can be controlled to achieve the desired effects in terms of conservation, while maintaining quality, safety and nutritional properties of the food. The biological effects of UV radiation depend on the wavelength and exposure time.

In the spectrum of electromagnetic radiation, UV radiation lies between the visible radiation and X-radiation and visible radiation, having wavelengths between 40 and 400 nm, and the energy range between 3 and 30 *eV*. UV spectrum comprises five distinct regions: extreme UV (40...190 nm); far UV (190...220 nm); UV-C (220...290 nm); UV-B (290...320 nm) and UV-A (320...400 nm) [3].

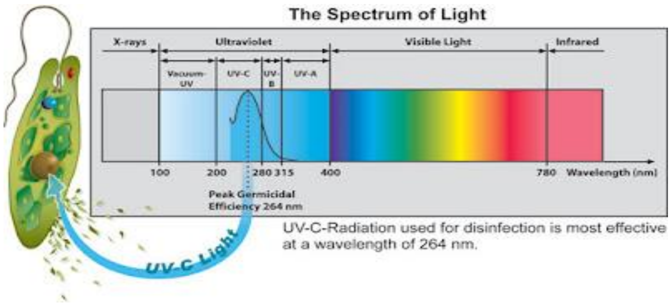

Fig. 6 *- Curve of germicidal efficiency of UV radiation on pathogens depending on the wavelength (nm)* [58]

UV radiation in the extreme UV and far UV-C are almost non-existent in nature, because they are completely absorbed in the atmosphere. Artificial sources of UV light are produced by lamps of low-pressure or medium/high pressure. Low pressure lamps produce essentially monochromatic light at a wavelength of 253.7 nm, very close to the peak of the curve of the germicidal efficiency of 264 nm. These lamps are available with the production of ozone or non-ozone producing. Medium pressure lamps produce a polychromatic light on a wider range.

- ***Factors that influence microbial inactivation***: pressure, temperature and pH of the medium do not seem to have a significant effect on absorption properties. On the other hand, product composition, dry matter content, colour and chemical composition of the food generally influence microbial inactivation. Another critical factor is the transmissivity of the material being disinfected. If the material is highly transparent to UV, disinfection may be more effective. On the other hand, materials with high optical density attenuate and scatter UV radiation, which leads to decrease the rate of inactivation. Geometrical configuration of the system is also important because attenuation increases with the road map. Another critical factor is the wavelength of UV radiation because it affects microbial inactivation.
- ***Microbial inactivation mechanisms***: shape of microbial inactivation curve by UV treatment is sigmoid. Initial plateau phase is due to microorganism damage by UV radiation. After this initial plateau, a minimum additional exposure is lethal to microorganism and survival rate decreases rapidly. The final part of the curve has a stationary phase due to the UV resistance of microorganisms and experimental components such as suspended solids, which can block UV radiation. Experimental data suggest that logarithmic reduction depends on the exposure to UV (J/m^2). For all microorganisms exposed to UV radiation of 254 nm, there was a 4-log reduction at exposures below 400 J/m^2.

Possibilities of using UV-C radiation as a post harvest treatment of horticultural products

Ultraviolet non-ionizing radiation UV-C is used to reduce microbial populations in foods as an alternative to chemical decontamination and was approved for use as a disinfectant in treating of exterior surfaces of products [14]. As post harvest treatment of horticultural products, irradiation with UV-C ultraviolet radiation has proven beneficial in reducing respiration rate, control of products depreciation and in delaying maturation and ripening processes in various fruits and vegetables, whole or chopped, such as apple, citrus, peaches, melons, grapes, tomatoes, lettuce, spinach and mushrooms [1, 2, 6, 7, 8, 10, 11, 12]. Also, UV-C ultraviolet radiation proved to be the trigger of biochemical responses in horticultural products, from induction of antifungal enzymes and to the formation of the fitoalexine category [9], all of which were positively correlated with resistance against pathogens and reducing physiological disorders occurring in low temperature storage time [13]. Another advantage of using UV-C radiation is the capability to improve the nutraceutical properties due to increased content in bioactive compounds with antioxidant capabilities.

Extending the life of the products is nowadays a challenge for research with application in food industry. The research undertaken to test decontamination methods in order to extend the period of validity of horticultural products fresh or minimally processed, focuses on five approaches:

1. Reducing infections and poisoning caused by ingestion of contaminated products;
2. Decrease product depreciation, caused by pathogens existing in products;
3. Keeping the attributes of freshness;
4. Keeping nutritional quality;
5. Avoid obtaining unacceptable levels of toxic residue or toxic sub-products.

Current status of achievement of technical equipment for decontamination, using non-ionizing ultraviolet radiation UV-C

UV-C ultraviolet radiation is already successfully used in various fields such as medicine (decontamination of air and medical instruments), ecology (wastewater), packaging industry (decontamination for various food packaging) etc. Worldwide there are concerns in using this method for decontaminating exterior surfaces of food. Companies like Lumalier Corporation (USA), DDK Scientific Corporation (USA), Trojan UV (Canada), UV technology (UK), LIT Ultraviolet Technology (Russia), GLA (Netherlands), MIDAS Electronics (Romania) etc., produce equipment decontamination of air, water, surfaces and products.

MIDAS Electronic (Romania) manufactures and sells equipment for disinfection of air, water, and food packaging.

Fig. 7 – *Equipment for air disinfection MidasAnAir 12015, 1224f, 3030, 3040, 3040i* [20]

Equipment for air disinfection equipment are used in public catering units, hospitals, chambers of archiving documents, museums, packaging rooms, public and private institutions etc.

Equipment for disinfection of packaging and products:

Fig. 8 – *Equipment for disinfection of packaging and products*
MidasAnAir SU Packaging, MidasAnAir SU Conveyor and MidasAnAir Eggs [20]

Equipment for water disinfection:

Fig. 9 *– Equipment for water disinfection, Water Sterilization Aqua Clean* [20]

Lumalier Corporation (USA) produces a wide range of UV disinfection equipment (fig. 10 and 11):

Fig. 10 *– Portable equipment for air disinfection TRU-D si EDU* [15]

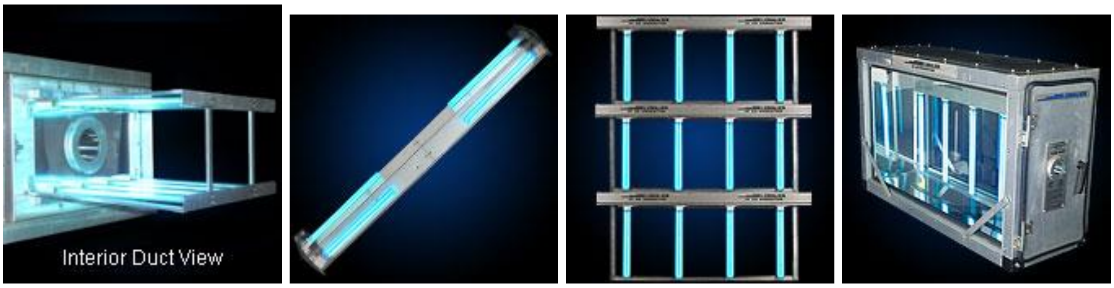

Fig. 11 *– Equipment for air disinfection in various fields* [15]

DDK Scientific Corporation (USA) has developed a wide range of sterilization equipment for natural fruit juices and bread treatment. In figure 12 are shown different construction types of such equipment.

Fig. 12 *- Equipment for sterilization* [16]

Trojan UV (Canada) produces a wide range of equipment for water disinfection: wastewater, drinking water, water in contaminated environment (fig. 13).

***Fig. 13 –** Equipment for disinfection* [17]

UV Technology (UK) has perfected a technology for disinfection of food, based on the use of UV-C. Development and commercialization of UV-C decontamination tunnels (fig. 14) allowed a wide range of food producers, from the bakery industry, the fruit processors to benefit from the advantages of these devices: extending the life products, reduce losses due to spoilage, improve product quality and reduce the risk of cross-contamination, keeping the organoleptic characteristics of the products for longer periods, reducing the use of chemicals, heat treatment, additives and preservatives.

***Fig. 14** - Tunnel for the decontamination of food* [18]

***Fig. 15** - Devices for air decontamination* [18]

***Fig. 16** – Equipment for decontamination of products and packaging* [18]

LIT Ultraviolet Technology (Russia) manufactures equipment for disinfection of water, air and surfaces (fig. 17, 18 and 19).

Fig. 17 *– Equipment for water decontamination* [19]

Fig. 18 *- Equipment for air decontamination* [19]

Fig. 19 *- Device for decontaminating products on the conveyor belt [19]*

CONCLUSIONS

Conditioning involves a series of operations aimed at bringing the products to the features provided by the standards of a particular way of recovery. On the other hand, keeping horticultural products in fresh state is a complex of physical and mechanical operations and a complicated physiological and biochemical process whose purpose is to maintain commercial acceptability of food products for a longer period of time.

UV-C ultraviolet non-ionizing radiation is used to reduce microbial populations in foods as an alternative to chemical decontamination and was approved for use as a disinfectant in exterior surface treatment products (US-FDA, 2002). As post harvest treatment of horticultural products, irradiation with UV-C ultraviolet radiation has proven beneficial in reducing respiration rate, control of depreciation products and in delaying maturation and ripening processes in various fruits and vegetables, whole or chopped, such as apple, citrus, peaches, melons, grapes, tomatoes, lettuce, spinach and mushrooms.

UV-C ultraviolet radiation is already successfully used in various fields such as medicine (decontamination of air and medical instruments), ecology (wastewater), packaging industry (decontamination for various food packaging) etc. Worldwide there are concerns in using this method for decontaminating exterior surfaces of food. Companies like Lumalier Corporation (USA), DDK Scientific Corporation (USA), Trojan UV (Canada), UV technology (UK), LIT Ultraviolet Technology (Russia), GLA (Netherlands), MIDAS Electronics (Romania) etc., produce equipment for decontamination of air, water, surfaces and products.

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