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ASPECTS REGARDING THE PRESERVATION OF FOODS WITH THE HELP OF HIGH PRESSURES

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Abstract: Food security is currently one of the main issues within the social policy of any civilized country. The preservation of food products, including those from the vegetable - horticultural sector, is performed according to a series of principles and methods that involve compliance with certain technologies depending on the purpose of the method. The paper presents aspects regarding the preservation of food products with the help of high pressures, as well as the current stage of the realization of technical equipment that uses this technology.
Keywords: foods, preservation, high pressure treatment, high pressure processing equipment

1. INTRODUCTION

Fruits and vegetables play an important role in human nutrition providing vitamins, minerals, fibers and essential nutrients. In order to prolong the marketing of these products and ensure nutrients throughout the year, preservation by different methods of fruit and vegetables is necessary *(Ingeaua et al., 2015)*. Consumed in fresh-state, horticultural products can be carriers of some optional pathogenic microorganisms: bacteria, yeasts, molds *(Sorica et al., 2015)*. Food safety and food-borne diseases remain a major public health concern. In the developed countries like the United States, the percentage of people suffering from food-borne diseases each year has been reported to be as high as 30%, thus reinforcing the need to ensure safe and nutritionally wholesome foods. Conventionally, food products are preserved by applying thermal processing methods like pasteurization, canning and/or using chemical preservatives *(Ronit et al., 2020)*.

Even though many food preservation methods have been developed over time, most of the current approaches impact the quality of foods and/or change the regular form and aspect *(Baisan, 2018)*.

The category of modern preservation methods includes thermal and athermal methods. The most important athermal preservation methods are:

≡ preservation using high pressures;
≡ preservation using the magnetic field;
≡ preservation using ionizing radiation;
≡ preservation using the pulsating magnetic field;
≡ preservation using ultra-short light pulses;
≡ preservation using ultraviolet radiation *(Lungu, 2020)*.

High pressure treatment (UHP), as a potential food preservation technique, was reported almost 100 years ago. This type of treatment has regained the interest of specialists around the world in recent years, probably due to the commercial success gained in Japan. In modern terms, high pressure treatment technology is a new, non-thermal processing technique by which products are subjected to high hydrostatic pressure, generally in the range of 100-600 MPa, at room temperature.

It has been shown that high pressure can significantly reduce microbial load and enzymatic activity, while changing the properties of ingredients and foods, with minimal unwanted modifications (inevitable with conventional heat treatment), such as: losses of flavor, color and nutrients. Given that UHP treatments distort proteins and polyglycerides, this technology is also of interest in the field of food texturing.

In both fields of application, preservation and texturing, the non-thermal character of the technology opens new opportunities for the food industry to make new products with superior sensory and nutritional qualities, with a new texture, much more convenient, much safer and with a higher commercial preservability.

Taking into account the fact that current consumer demands are mainly for "fresh" products, high pressure, especially in combination with a moderate heat treatment, offers possibilities for the realization of new products with improved sensory properties.

For the past 20 years, the interest of food processors has focused on high-pressure processing. The Japanese were remarkably successful in obtaining high-pressure processed foods in the 1980s. High-pressure processed foods, already available on the Japanese market, include a rich assortment of fresh fruit-flavored jams, souces and dressings for salads, ready-to-eat desserts, grapefruit and tangerines juices with the same flavor as the "freshly squeezed" product. Fruit juices are also available in France, and avocado puree (guacamole) obtained by processing at high pressures is one of the best-selling products in the United States *(https://jurnalul.ro/viata-sanatoasa/trup-minte-suflet/tehnologie-presiuni-inalte-alimente-sanatoase-128688.html)*.

High Pressure Processing (HPP) has been gaining popularity in Portuguese speaking countries, especially in Brazil and Portugal. This interest is due to an increase in the demand for healthier and natural foods, which can be achieved by using a non-thermal preservation method such as HPP *(http://blog.hiperbaric.com/en/)*.

Current commercial applications of high pressure treatment technology can be achieved in two fundamentally different ways, namely: in the container, which means that the high hydrostatic pressure treatment process is performed after filling and sealing the product in the final or intermediate packaging, or in bulk followed by aseptic packaging. The applications of high hydrostatic pressure that can currently be found worldwide are presented in Table 1 *(https://www.proiecte.ro/industria-alimentara/procesarea-produselor-alimentare-cu-presiune-inalta-70505)*:

Table 1. Commercial applications of high hydrostatic pressure treatment

Aplication domain	Processing conditions		
	Pressure [Mpa]	Temperature [°C]	Duration of a pressurization - depressurization cycle
Cold isostatic pressing (CIP)	50-600	temperature	0.3-5 min
Warm isostatic pressing (WIP)	200-400	200- 250	minutes
Hot isostatic pressing (HIP)	100-400	1000-2000	5-10 hours
Quartz crystal growth apparatus	200	430	4-6 weeks
Simulators	miscellaneous	miscellaneous	miscellaneous
Chemical reactors	200-250	300	months (continuous)

Regarding the processing of food liquids at high pressure, Table 2 presents the advantages and disadvantages of the two systems, namely in container and bulk.

Table 2. Advantages and disadvantages of high pressure processing

Advantages	
Container treatment	Bulk treatment
Applicable to all types of food, both liquid and solid	Simple handling materials (pumps, pipes, valves, etc.)
Minimal risks of contamination after treatment	High flexibility of the container (can be made of glass, metal, etc.)
The high pressure treatment part is ready to use (available). No major changes are required	Maximum efficiency of the volume of high pressure vessels (> 90%)
	Minimum downtime for the treatment vessel (quick loading / unloading, no closing / opening required)
Disadvantages	
Container treatment	Bulk treatment
Handling of complex material	Applicable only to pumpable products
Low volume efficiency (50-70%)	Aseptic packaging is still required due to the increased risk of contamination after treatment
Low container flexibility	Requirement for aseptic design of all high pressure components in contact with food
High dead times of high pressure vessels (loading / unloading, filling, opening, closing)	

2. MATERIAL AND METHOD

The food industry has experienced a constant development in recent years, and has been identified so far different methods and techniques for food preservation *(Baisan, 2018)*.

The high pressure treatment method is used to inactivate certain microorganisms and enzymes, with a direct consequence on prolonging the shelf life of food. The level of inactivation of microorganisms depends, however, on a number of factors, such as: pH, product temperature and the level of water activity in the product. The mechanism of inactivation consists in the destruction of the cell membrane, accompanied by the elimination of cell juice. The pressure level to which the packaged food is subjected varies between 3-12 kbar, depending on the type of microorganisms to be inactivated. Despite the high value of pressures, the product does not undergo physico-chemical changes. Inactivation of the most resistant bacterial spores requires, however, the combination of high pressure treatment with light heat treatment.

Following detailed research on UHP treatments, the mechanism of destruction of microorganisms has been established, namely: the lethal effect on bacterial spores occurs mainly when the pressure is lowered and the pressurized water moves with a very high rate of adiabatic expansion. . Based on this principle, the pressurization and depressurization cycles are those that give the treatment efficiency in inactivating the spores, more than the UHP treatments with prolonged maintenance time or higher temperatures. The effects of UHP on yeasts and molds are shown in Table 3. *(https://www.proiecte.ro/industria-alimentara/procesarea-produselor-alimentare-cu-presiune-inalta-70505):*

The most suitable products for the treatment of UHP are fruit-based products (juices, nectar, fruit creams), which have a high value of water activity, but, lately, numerous studies and research have focused on the effect of these treatments on the functional properties, namely, on some components of various food products, such as: starch, proteins, vitamins.

Table 3. Effect on yeasts and molds when using UHP treatment (23 °C; 10 min)

Product	pH	Initial no./ml	No./ml after 2000 kg/cm^2	No./ml after 3000 kg/cm^2
Oranges	3.4	5.2 xl0^3	1.2 x 10^2	0
Lemons	2.5	1.4x10^3	2	0
Tangerines	3.8	2.0x10^3	2.7x10^2	0

3. RESULTS

There are many well-recognized processing technologies, developed worldwide in the field of food science and technology and currently being marketed for the transformation of raw materials into various edible foods.

In this context, Avure Technologies produces high pressure processing installations, from the AV-20M, AV-30M and AV-40M range.

Figure 1. HP-AVM 20M, AV-30M and AV-40M systems (https://www.avure-hpp-foods.com/)


Figure 2. HP-AVX 40X, AV-50X, AV-60X and AV-70X systems (https://www.avure-hpp-foods.com/)

These installations can be easily extended depending on the hourly processing capacity, from 1300 kg to 1800 kg and 2300 kg respectively, depending on the working process. Table 4 presents the technical characteristics for each installation model.

Table 4. Technical characteristics

Model	AV-20M	AV-30M	AV-40M
Number of high pressure pumping units (K22A)	0.5	1	2
Number of pressure lifters	2	4	8
Standardized annual working capacity / Pressure holding time: 1 minute	12,000,000 kg	19,000,000 kg	26,800,000 kg
Standardized annual working capacity / Pressure holding time: 3 minutes	10,000,000 kg	14,200,000 kg	18,100,000 kg
Standardized working capacity per hour / Pressure holding time: 1 minute	1,500 kg	2,400 kg	3,400 kg
Standardized working capacity per hour / Pressure holding time: 3 minutes	1,300 kg	1,800 kg	2,300 kg
Number of cycles / hour / Pressure holding time: 3 minutes (50/60 Hz)	5.4	7.7	9.8
Utility requirements			
Cold water	220 L/min		
Current source (three-phase / 480V / 60 Hz)	160 kVA 190 A 150 kW	310 kVA 370 A 290 kW	600 kVA 720 A 570 kW
Current source (three-phase / 400V / 50 Hz)	160 kVA 220 A 150 kW	290 kVA 420 A 280 kW	580 kVA 830 A 550 kW
Air source	7 bar and 100 L/min		

Table 5. Technical characteristics

Model	AV-40X	AV-50X	AV-60X	AV-70X
Number of high pressure pumping units (K22A)/Each pump includes 4 pressure lifters	1	2	3	4
Standardized annual working capacity / Pressure holding time: 1 minute	25,330,000kg	37,420,000kg	46,050,000kg	48,930,000kg
Standardized annual working capacity / Pressure holding time: 3 minutes	19,570,000kg	25,900,000kg	28,780,000kg	31,660,000kg
Standardized working capacity per hour / Pressure holding time: 1 minute	3,247 kg	4,797 kg	5,904 kg	6,273 kg
Standardized working capacity per hour / Pressure holding time: 3 minutes	2,509 kg	3,321 kg	3,690 kg	4,059 kg
Utility requirements				
Cold water	300 L/min at 1 °C			
Current source (three-phase / 480V / 60 Hz)	890 kVA 1070 A 750 kW			
Current source (three-phase / 400V / 50 Hz)	850 kVA 1230 A 725 kW			
Air source	6 bar and 200 L/min			

The installations from the AV-40X, AV-50X, AV-60X and AV-70X range are presented below. These installations can be easily extended depending on the hourly processing capacity, from approx. 2500 kg to 3300 kg, 3700 kg and 4000 kg respectively, depending on the work process. Table 5 presents the technical characteristics for each installation model

Hiperbaric is the world's leading company specialised in the design, manufacture and marketing of industrial equipment using High Pressure Technologies.

The Hiperbaric In-Pack range of industrial equipment for high pressure processing of packaged products is the widest on the market. It is composed of equipment with vessels or processing chambers of different capacities, meeting the requirements of all our clients from start-ups or SMEs to large multinational companies. All equipment works with a maximum pressure of 6,000 bar (600 MPa / 87,000 psi) *(http://blog.hiperbaric.com/en/)*. The equipments that use high pressure technologies from the Hiperbaric range are presented in the figures below. Table 6 presents the technical characteristics for each model:

Figure 3. Hiperbaric 55

Figure 4. Hiperbaric 135

Figure 5. Hiperbaric 300

Figure 6. Hiperbaric 420

Figure 7. Hiperbaric 420

Table 6. Technical characteristics

Model	Hiperbaric 55	Hiperbaric 135	Hiperbaric 300	Hiperbaric 420	Hiperbaric 525
Throughput, kg/hour [pounds/hour]	270 [590]	670 [1,480]	1,410 [3,100]	2,600 [5,730]	3,210 [7,080]
Vessel Capacity, liters [US liq. Gallons]	55 [14.5]	135 [36.7]	300[79.3]	420 [111]	525 [150]
Vessel diameter inside, mm [inches]	200 [7.9]	300 [11.8]	300 [11.8]	380 [15]	380 [15]
Dimensions, meters [feet]	L: 8 [26.2] W: 2.8 [6.8] H: 2.2 [7.2]	L: 10.2 [33.4] W: 3.2 [10.6] H: 2.6 [8.5]	L: 17.4 [57] W: 4.4 [14.4] H: 4.3 [14]	L: 17.2 [56.4] W: 4.4 [14.4] H: 4.3 [14]	L: 18.5 [60.6] W: 4.4 [14.4] H: 4.3 [14]

4. CONCLUSIONS

The high pressure treatment method is used to inactivate certain microorganisms and enzymes, with a direct consequence on prolonging the shelf life of food. The level of inactivation of microorganisms depends, however, on a number of factors, such as: pH, product temperature and the level of water activity in the product.

The most suitable products for the treatment of UHP are fruit-based products (juices, nectar, fruit creams), which have a high value of water activity, but, lately, numerous studies and research have focused on the effect of these treatments on the functional properties, namely, on some components of various food products, such as: starch, proteins, vitamins.

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