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SOME ASPECTS REGARDING THE FOOD STABILITY AND THE FACTORS THAT INFLUENCE IT

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Abstract

One of the specific features of food is perishability, and therefore it is very important to know and control the factors that influence their stability and the processes capable of producing qualitative changes and the possibilities of stabilizing them for as long as possible. The main factors which influencing the food stability are: enzymes, microorganisms and water content. The microorganisms and enzymes act on carbohydrates and lipids of the food and turn them through fermentation and putrefaction processes. As a result, the chemical composition of food undergoes changes and may appear the complete destruction of nutrients, the products becoming unfit for consumption. Increasing of the food product stability is necessary to eliminate the seasonal nature of consumption, to increase availability for consumers and to reduce losses of the perishable food. In this respect, is used some processes for the relative stabilization of food products properties, which involve various additional technological operations, as a result of which the products undergo physical, chemical and biochemical changes. Improving the food stability in safe conditions can be achieved by various processes which, in general, refer to the separation of microorganisms by physical processes; reducing or stop development of microorganisms; destruction by various means of microorganisms; combined methods. Technological processes are constantly evolving; more and more modern methods appear to extend the shelf life of a food. Notable examples in this regard are high pressure, radiations, ultra-short light pulses or magnetic field protocols. There are also microwave devices that have the same purpose - to preserve the nutritional properties of some food products for as long as possible.

Key words**:** *food products, stability, factors, processes*

INTRODUCTION

Food products are vital importance because it is the daily feed of people, providing the necessary energy and nutrients. Through their properties, food products can improve, maintain or on the contrary, can affect the consumer's health [7, 9, 12, 14].

The quality of food products is a particularly complex notion, which takes into account consumer safety, which has become a disqualifying competitive element for the market of these products. The quality of food products is determined and influenced by a series of factors that act both in the production process and in the process of product circulation, in all stages of the product trajectory, from identifying consumer requirements to satisfying them and assessing their satisfaction [2]. The dynamic character of food quality is determined by scientific progress on the one hand [8, 10, 11, 13] and on the other, by the growing demands of well-informed and educated consumers regarding the quality of products.

In the modern economy, one of the fundamental principles of food quality management is consumer orientation. This orientation has as essential objective the satisfaction of the needs and preferences of the consumers regarding the type and the assortments of the food products; food characteristics: organoleptic, physical, chemical, biological (nutritional, microbiological, toxicological), technological, aesthetic; the sources of provenance of the food products and the technical processes used for their manufacture, etc. [1, 3, 6].

The main factors which influencing the food products stability are enzymes, microorganisms and the water content of those products. Enzymes are organic substances of a protein nature, secreted by the living cell and which act as biocatalysts (initiate and increase the speed of intra or extracellular chemical reactions thousands/million times). Characteristic of enzymes is the fact that they have specificity of action, in the sense that an enzyme catalyses only a certain reaction (degradation or association) and only for a certain substance that it recognizes chemically (substrate). Enzymes, found in raw materials or induced in the processing process, can act not only at the time of processing but also later.

Like any catalyst, enzymes are not consumed in the chemical reaction they catalyse. Their action is optimal at certain environmental parameters (temperature, pH), but like any protein they are thermolabile being denatured at high temperatures (over 100^0C) and long lasting [14].

With regard to microorganisms, a permanent control must be established over them, to block their multiplication mechanism by bacteriostatic means and use physical and chemical agents to destroy unwanted forms. Due to their chemical composition, food products have a favourable nutritional environment for the development of microorganisms, being an excellent source for energy procurement and the development of their metabolic activity. Temperature is an external factor that contributes greatly to the diversity and variability of microorganisms. Microorganisms that can inhabit in foodstuff are classified according to temperature, in: microorganisms with optimum at room temperature 20-30^0C; microorganisms with optimum at human body temperature (37^0C), including pathogenic microorganisms; microorganisms with the optimum at the current coagulation temperature of protein substances (i.e., above 50^0C), called thermophilic microorganisms.

As regards microorganisms, both in the manufacturing process and in the storage and marketing of many food products, the most different species are involved, either with positive or negative action for the properties, respectively for the quality of the products [1, 4, 6]. In this sense, the microorganisms can be grouped in:

- Saprophytic microorganisms of culture, used for useful transformations of the foods and that are part of the current technologies in bakery, vinification, in the manufacture of cheeses, etc.
- Saprophytic degradation microorganisms (moulds, yeasts, bacteria), which cause undirected microbiological processes, which result in unwanted changes or even alterations of food;
- Conditioned pathogenic and pathogenic microorganisms, which through the toxins produced at the level of food (toxic type) or at the level of the human body (infectious type) cause serious diseases, sometimes fatal.

In order to prolong the consumption of some seasonal agricultural products, the companies in the field of food production proceeds to the application of some preservation techniques in order to maintain the qualitative level of the foods (nutritional value and sensory properties) for a longer period of time. In this way certain foods can be consumed at any time of the year. The basis of food preservation is the four biological principles: biosis, anabiosis, cenoanabiosis and abiosis [2, 14, 16].

Biosis is based on the ability of living organisms to counteract the harmful action of bioagents through the mechanism of natural immunity. For this, it is necessary to monitor the storage parameters (light, relative humidity, temperature, air circulation, microorganisms) at the optimal values necessary to maintain the quality level for as long as possible.

Anabiosis is based on slowing down the metabolic process of agricultural food product by applying special techniques (dehydration, increasing osmotic pressure, low temperatures, etc.).

Cenoanabiosis consists in creating optimal conditions for the development of certain microorganisms (yeasts, lactic acid bacteria) which through their activity prevent the development of degradation processes of agricultural products.

Abiosis is based on the destruction or removal of microorganisms from the agricultural product through special methods (pasteurization, sterilization, use of food preservatives, etc.).

MATERIALS AND METHODS

This is a documentary study about the main elements of the notion of food stability and the factors that influence this property to ensure extend of the shelf life of food products, food safety and consumer protection. We considered this research useful given that the consumer protection has become a global issue. The European Commission emphasizes that the highest priority of the EU is to protect the health and safety of consumers and to ensure the fairness of the practices used in the food trade, through a series of deontological rules (codes), standards and recommendations.

RESULTS AND DISCUSSIONS

The stability of food products refers to their ability to retain over time the initial qualitative and quantitative characteristics and their resistance to handling and transport. This property is associated with the notion of perishability, because all foods change their initial characteristics over time. From this point of view, vegetables and fruits are grouped into four categories (Figure 1):

1. Excessively perishable: vegetables grown for the vegetative part (salad, parsley, dill, larch, etc.) and fruits with thin epidermis and very high respiration intensity (strawberries, raspberries, currants, etc.);
2. Very perishable: vegetables and fruits with thin epidermis (mushrooms, cucumbers, green onions, zucchini, cherries, sour cherries, apricots, peaches, etc.);
3. Perishable: vegetables and fruits resistant to storage and transport (cauliflower, melons, eggplants, apples, pears, grapes, etc.);
4. Less perishable: vegetables and fruits with a good ability to maintain quality and which are usually consumed more in winter (onions, carrots, winter radishes, beets, garlic, some varieties of apples, pears, quinces, etc.).

The main factors which influencing the food products stability are enzymes, microorganisms and the water content of those products.

In order to extend the shelf life of agricultural products, three factors must be taken into account: food processing conditions, packaging conditions and environmental conditions (Figure 2).

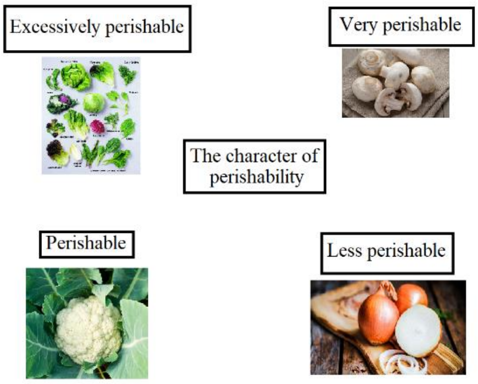

Fig. 1. The perishability character of fruits and vegetables
Source: [1].

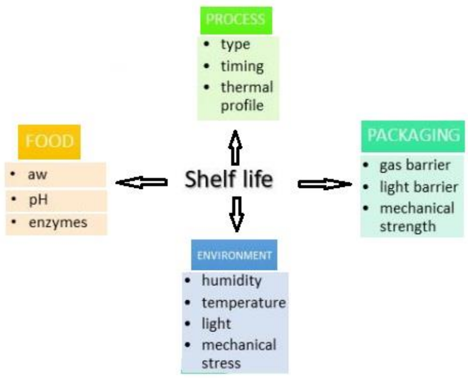

Fig. 2. The factors that influencing the prolongation of the shelf life of agricultural products
Source: [6].

Depending on the temperature at which they are active, the microorganisms can be classified into: psychrophiles, mesophiles and thermophiles. The minimum, optimal and maximum temperatures levels at which they activate are shown in Table 1.

Table 1. The minimum, optimal and maximum temperature levels (^{0}C) at which the microorganisms are activate

Group/ Temperature	Minimum	Optimum	Maximum
Psychrophiles	0	20-30	35-40
Mesophiles	15-20	30-40	≥45
Thermophiles	≥45	55-65	≥90

Source: [4].

The moulds are multiplied under natural conditions at low temperatures (10-20^{0}C); some prefer slightly higher temperatures, such as parasitic species that prefer human body temperature. Yeasts tolerate wider thermal variations. Cryophilic microorganisms generally grow around 0-10^{0}C.

Another external factor that can influence the activity of microorganisms is light. The orange and yellow radiation in the electromagnetic spectrum is indifferent, the green radiation is stimulating and the ultraviolet (UV) radiation is destructive to microorganisms. For this reason, decontamination is practiced with the UV lamps.

The pH level of food influences the activity of different types of microorganisms, taking into account the fact that most bacteria grow at a pH=6.5-7.5. When the pH value is outside these limits, development slows down and at a pH value of 8 it stagnates. On the other hand, yeasts and moulds prefer more acidic medium; some of them can develop even at a very low pH level (2-3). Among other external factors which influencing the activity of microorganisms can be listed: electricity, osmotic pressure, surface tension, ionizing radiation, etc. [4, 6, 14].

The microorganisms (bacteria, yeasts and moulds) and enzymes act on carbohydrates and lipids of the food and turn them through fermentation and putrefaction processes. As a result, the chemical composition of food undergoes changes and may appear the complete destruction of nutrients, the products becoming unfit for consumption.

Fermentation processes are produced by the enzymes of anaerobic microorganisms. These microorganisms produce chemical transformations mainly on carbohydrates, with the formation of a main product (in larger quantities) and by-products (in smaller quantities). The name of the fermentation comes from that of the resulting main product, so it can be: alcoholic (ethyl alcohol), acetic (acetic acid), lactic (lactic acid), butyric (butyric acid) etc. Each type of fermentation is related to the activity of specific enzymes.

Fermentation processes are accompanied by the release of energy or, as the case may be, by certain gases. A small part of the released energy is used by microorganisms, and the rest passes into the environment causing the heating of the substrate to cereals, fresh vegetables and fruits, fresh meat, etc. which, placed in piles, are heated or carbonized. The food industry directs the fermentative enzymatic processes through specific technological processes, in order to obtain products such as: alcohol, beer, citric acid, etc.

Alcoholic fermentation consists in the transformation of simple fermentative sugars (glucose, mannose, galactose, fructose, etc.) into ethyl alcohol and carbon dioxide. The bioagents that cause alcoholic fermentation and that produce in various proportions ethyl alcohol are: yeasts of the genus Saccharomyces, moulds (*Mucoraceae, Penicillium glaucum*), bacteria (*Bacillus aethylicus*), etc.

Alcoholic fermentation occurs during the storage of food products (fresh vegetables and fruits, jams, marmalades, syrups, juices, etc.) in conditions of improper storage, or as a result of improper preparation of products for storage (e.g., insufficient boiling, content insufficient sugar, etc.). In the food industry, alcoholic fermentation is directed through various technological processes that underlie the manufacture of wines, beer, alcohol, various bakery products, etc.

Acetic fermentation is produced by the enzymes of acetic bacteria and consists in the oxidation of alcohol contained in acetic acid products, the products acquiring a sour, pungent taste. As in the case of alcoholic fermentation, acetic fermentation too is the basis for obtaining food products. In most cases, however, it is an undesirable phenomenon, contributing to the depreciation of food stored in improper conditions (wine vinegar, beer spoilage, acidic dairy products, etc.). Favouring factors are oxygen and the temperature of 25-30^{0}C.

The lactic fermentation takes place under the action of lactic acid bacteria and consists in the transformation of carbohydrates (glucose, lactose, fructose, mannose, galactose, glycogen, etc.) from products into lactic acid.

Lactic bacteria are of two types:

1. True lactic bacteria (the genus *Termobacterium*, which includes *Bacillus lactis, B. helveticum, B. casei, B. yogurti*, etc., with the optimum activity at 30^{0}C);
2. False lactic bacteria (*Bacterium aerogenes*) producing gases (carbon dioxide and hydrogen), which degrade food products.

The lactic bacteria have an important role in the food industry, the favourable action of this fermentation being applied in a directed way to obtain many dairy products (yogurt, sour milk, cream, cheese) as well as to preserve vegetables by pickling, etc. The presence of lactic acid in a certain concentration in acidic dairy products or in pickled products prevents the development of spoilage microorganisms and especially those of putrefaction. However, these products cannot be stored for a long time, because the acidic environment favours the development of yeasts and moulds that consume lactic acid, the environment becoming alkaline and facilitating the development of putrefactive microflora.

Butyric fermentation takes place in the absence of air, under the action of butyric bacteria and consists in the transformation of sugars into butyric acid. Butyric bacteria are very widespread in nature (soil, dirty water, etc.) and grow intensely at temperatures between 35 and 40^{0}C. Butyric fermentation occurs during the improper storage of pickled products, cheeses, milk, etc., which acquire a bitter taste and unpleasant odour. Cheeses with buttery bloating are recognized by their strongly swollen shell, soft consistency, sweet taste and strong odour of butyric acid. The milk attacked by the butyric bacteria acquires a bitter taste [1, 4].

Putrefaction is a microbiological process caused by putrefactive bacteria (aerobic and anaerobic) and less often by the action of mould. The main aerobic (and optionally anaerobic) putrefaction bacteria are: *Bacillus mesentericus, B. proteus, B. fluorescens, B. subtilis*, *E. coli* and among the anaerobic putrefactive bacteria are mentioned: *Bacterium putrificus, B. sporogenes* and *Clostridium perfringens*. The development of these bacteria is favoured by high temperature and high humidity [5].

Putrefactive bacteria mainly attack protein substances causing profound amino acid transformations. As a result of these transformations, various aliphatic acids (oxyacids, polybasic acids), aromatic acids, amines, ptomaines, phenols, mercaptans, various gases (CO_2, NH_3, H_2S, CH_4) appear in different products. Many of these substances are toxic or very toxic: putrescein, cadaverine, indole, scatole, mercaptans, amines (histamine, tyramine, etc.) [4].

All rotting food has a repulsive odour and is unfit for consumption. Fish is very sensitive to the onset of putrefaction processes, because the mucus that covers the body of the fish easily fixes microorganisms, constituting an environment conducive to their development. Bacteria can also penetrate more easily into the muscle tissue of fish that is less dense than warm-blooded animals and contains less connective tissue. Rotten eggs have a cloudy, opaque or coloured content in red, green or black. The foul smell of sauerkraut indicates an advanced process of putrefaction.

Mouldy foods came from a form of microbiological spoilage of these. Biological agents are mould whose colonies specifically stain (by species) the infected surface of the products, in white, yellow, green, brown and black. The action of moulds consists in the hydrolysis of polysaccharides (to ensure their nutrition), proteins, lipids, as well as in various chemical and biochemical transformations (oxidations, fermentations, etc.). Mouldy foods contain mycotoxins and as such are eliminated from human consumption [1, 6].

Moulding process occurs on products with high-water content (cheese, vegetables, fruits, etc.) or even on products with a lower humidity but kept in a humid environment. For example, bread moulding occurs when it is stored in conditions of relative air humidity above 80%; the mould develops on the surface of the bread, then penetrates inside through the cracks of the crust, making it unfit for consumption. Sausages kept in high humidity conditions are covered with mould, which also penetrates inside the product if it has air gaps. The eggs mould in an environment with a humidity of over 85%, acquiring the appearance of a stained egg and the smell of mould. Cheeses usually mould under the shell, especially if it is cracked. In some cheeses, moulding is not a defect, as it is controlled by the use of noble moulds during ripening (*Penicillium roqueforti* in Roquefort cheese and *Penicillium camemberti* in Camembert cheese).

The stability of food products is a feature intrinsically linked to the variation of their water content. Either by reducing the water content (dehydration), or by binding it to the food by salt or carbohydrates, it is possible to influence the way in which certain microorganisms grow, improving the tolerance to food storage. Another role of water is to form the texture of food following interactions with proteins, polyglucides, lipids and mineral salts.

Water influences directly the quality of products (in food products, water it is found in free or bound form). Having the role of dissolving other chemicals in its mass, water is a nutrient necessary for the activity of bacterial enzymes. Therefore, the water content of food is monitored and specified in standards, as an essential element on which are established the conditions and duration of food storage. Also, the water content influences the consumer's perception of some characteristics of the products, such as freshness.

The water content respective dry matter content is an indicator of quality, especially for products in which the correction of humidity to optimal values is possible and necessary, such as: cereals, cheeses, meat products, sugar products, etc. The water activity (*aw*) specific to a food varies according to its moisture content, so that for different foods, the same aw value corresponds to some different humidity values (Figure 3).

Above a certain minimum value of *aw*, the metabolism of various microbial species ceases. This minimum value is a characteristic of the species and depends on the ability of the microbial cytoplasm to retain a greater or lesser amount of water: when the amount of water retained by the cytoplasm of the microbial cell is higher, the limit value characteristic of the species is small.

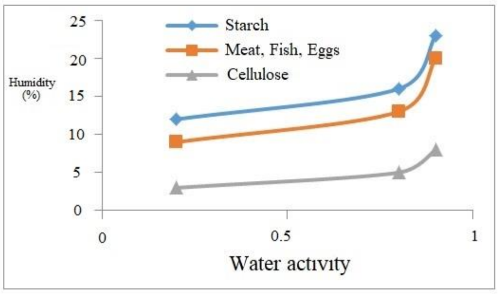

Fig. 3. The relationship between humidity and water activity
Source: [14].

In general, it is considered that microorganisms stop multiplying at aw = 0.7. The *aw* value of 0.7 at a temperature of 20^0C varies for different foods, depending on the humidity, as follows: for powdered milk it is reached at 7% humidity, for lean meat and dehydrated fish at 10% humidity and for beans and soybeans at 9-13% [1].

A wide variety of foods are slightly degradable: meat products, dairy products butter, cheese, fats and oils, confectionery and bakery products, etc. The modern methods of prolonging the stability of food (especially of slightly degradable products) include thermic and athermic methods.

The main *athermic* methods for improving food stability are given below:

1. Food preservation through high pressure - destruction of vegetative forms of microorganisms under the action of high pressures (4,000-10,000 Bar). The high pressures have the following effects: inactivation of some enzymes due to denaturation of their proteins part; modifying the tertiary and quaternary structure of proteins, increasing digestibility and their susceptibility to protease attack; changing the melting point of fats; intensifying the aroma of some food products by disorganizing some

cellular organs that release proteolytic enzymes that act on proteins with the formation of taste substances, etc. [16].

2. Food preservation through magnetic field. The oscillating and static magnetic field exerts a lethal effect on microorganisms due to the following damaging actions: at the level of cell membranes; on DNA and altered DNA synthesis; changing the flow of ions (Ca2 +) through the membrane.

The advantages of this method are the following: it preserves the sensorial and nutritional quality of the food product; the food products can be treated in flexible plastic packaging. In addition, the application of the magnetic field is not dangerous for operator.

3. Preservation with ultra-short light pulses - products of laser generators or lamps (flash). It destroys microorganisms on the inner surface of packaging, leading to an extension of shelf life of food, especially when refrigerated or frozen storage is practiced.

Use of the ultra-short pulses of light has been extended on the replacement of thermal sterilization of fruit juices, beneficial effects being obtained in the case of cherry juice, where the shelf life has been considerably increased. Other achievements in this area are increasing the shelf life of chilled tomatoes to about 30 days, keeping the fresh appearance of bread for more than 15 days or purifying water and liquid foods [15].

4. Preservation by high voltage pulsating electric field. It is applied to liquid foods, the effect manifesting itself in the cell membrane. The process has no negative effects on nutritional value and sensorial properties of treated food products.

5. Food irradiation is used in several countries to prolong stability and prolong shelf life. From this point of view, the irradiation method is applied to food for the following reasons: to destroy microorganisms in vegetables and spices, to prevent sprouting and germination of potatoes, onions and garlic, to kill or sterilize harmful insects from cereals, nuts and vegetables, to delay the ripening and ripening of fruits and vegetables, etc.

Irradiated foods must follow strict labelling guidelines, which vary by country. Testing should be performed using an appropriate method for the product to obtain reliable results.

The main *thermic* methods for improving food stability are [16]:

1. Preservation by ohmic heating. It is applies to more or less viscous liquids food products, with a certain solid/liquid ratio. This procedure is falls as a UHT system and the lethal effect on microorganisms is due to heat and electricity.

2. Preservation by heating with radio waves. It is a dielectric heating process, with concomitant pasteurization and freezing by continuous flow of meat compositions, intended for obtaining meat products with a diameter of up to 50 mm. The characteristics of the field from where they are: λ = 10-100 mm, frequency 3-30 MHz (short radio waves).

3. Preservation with infrared radiation, which can be with λ = 0.75-2.5μ (short), λ = 2.5-25μ (medium), λ = 25-750μ (large). They are used in the meat industry, for drying cereals, lactose, baking bread, biscuits and pastry.

4. Preservation with antiseptic substances (Table 2).

Table 2. Examples of slightly degradable food products and antiseptics used in the food industry to increase food stability

Antiseptic	Type of food	Dose
Ascorbic acid, sorbates	meat products	200 mg/kg
	margarine, butter	1,000 mg/kg
	cheese	500 mg/kg
	fats and oils	500 mg/kg
	fruit juices, syrups	1,000 mg/kg
	dried or frozen fruits	200 mg/kg
	bakery products	1,000 mg/kg
	confectionery products	500 mg/kg
	wine	1,000 mg/kg
Benzoic acid and its salts	caviar, mayonnaise	1,000 mg/kg
	canned fish	300-500 mg/kg
	fruit salads	100 mg/kg
	olives	100 mg/kg
Sulphites and sulphates	jams	25 mg/kg
	dehydrated fruits	60 mg/kg
	tomato sauce	100 mg/kg
	fruit concentrates	200 mg/kg
	potato flakes	400 mg/kg

Source: [16].

Antiseptics are substances that stop the development and action of microorganisms (bacteriostatic substances) or destroy them (bactericidal substances), depending on the concentration and species of the microorganism. The main factors that influencing the action of antiseptics are: concentration of substances, duration of contact, temperature, species and number of microorganisms in the substrate, the stage of development of microorganisms, the chemical composition of the medium culture and its pH [16].

Numerous studies have been conducted on the use of microwaves to improve food stability [17-20]. Thus, equipment and installations were made for the pasteurization and sterilization of food liquids, but also of meat and meat products, fruits and vegetable, canned fruits, ready to eat foods, bakery and pastry products, etc. Microwaves can reduce microbial flora, bacteria, moulds and other microorganisms harmful to food, by the thermal effect achieved, the food being passed through a microwave field.

Use of modern methods and techniques for preserving and prolonging the shelf life of food allows ensuring optimal conditions for storage, transport and distribution of food, with minimal losses of nutrients. At the same time, there are low consumptions of energy and auxiliary materials, compared to other conservation technologies, an undeniable advantage in terms of economic implications.

CONCLUSIONS

From the end of the technological process, food products maintain their physico-chemical, sensory and microbiological properties for a certain period of time, specific to each product and only under certain environmental conditions (temperature, relative humidity, light and other radiation, air circulation, microorganisms), after which changes in quality slower or faster, in negative sense, culminating with the alteration of the products. Foods have a lifespan that depends on their nature, chemical composition, preservation method, technological process, packaging, storage conditions, handling and transport.

The stability of food products refers to their ability to retain over time the initial qualitative and quantitative characteristics and their resistance to handling and transport. Improving the food products stability is an important element in ensuring their quality. The main factors that influence the food products stability are internal factors (pathogenic microorganisms) and external factors (temperature, humidity, chemical compounds in the structure of the package, etc.). For each food product is experimentally established the minimum quality assurance period, under prescribed conditions (temperature, relative air humidity, etc.).

The modern methods of prolonging the stability of food products include thermic methods (e.g. ohmic heating, heating with radio waves, use of antiseptic substances, etc.) and athermic methods (e.g. high pressure, magnetic field, ultra-short light pulses, etc).

REFERENCES

[1]Barzoi, D., Apostu, S., 2002, Microbiology of food products (Microbiologia produselor alimentare), Risoprint Publishing House, Cluj Napoca, pp. 110-128.
[2]Bonciu, E., 2017, Food processing, a necessity for the modern world in the context of food safety: a Review, Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series, Vol. 47(1):391-398.
[3]Butnariu, M., Smuleac, A., Dehelean, C., Chirita, R., Saratean, V., 2006, Studies concerning fertilizer influence (NPK in different doses) on quantity of corn plants chlorophyll, Journal of Chemistry (Revista de Chimie), 57(11): 1138-1143.
[4]Jelea, M., General microbiology. Cours notes (Microbiologie generala, Note de curs), pp. 7-10, http://chimie-biologie.ubm.ro/Cursuri%20on-line/jeleamarian, Accessed on 30.06.2021.
[5]Mehdizadeh Gohari, I., Navarro, M.A., Li, J., Shrestha, A., Uzal, F., A. McClane, B.A., 2021, Pathogenicity and virulence of *Clostridium perfringens*, Virulence, Vol. 12(1): 723-753.
[6]Pop, M., Food Merceology. Cours support (Merceologie alimentara, Suport de curs), pp. 113-116, https://docplayer.net/48555778-Merceologie-alimentara.html, Accessed on 30.06.2021.
[7]Paraschivu, M., Cotuna, O., 2021, Considerations on COVID 19 impact on Agriculture and Food Security and forward-looking statements, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol. 21(1): 573-581.
[8]Partal, E., Dima, F.M., Paraschivu, M., Cotuna, O., 2021, Fertilization effects on maize crop in the context of climate change, Romanian Agricultural Research, no. 38, pp. 357-362.

[9]Paraschivu, M., Ciobanu, A., Cotuna, O., Paraschivu, M., 2020, Assessment of the bacterium *Erwinia amylovora* attack on several pear varieties (*Pyrus communis L*.) and the influence on fruits sugar content, Agricultural Sciences & Veterinary Medicine University, Bucharest, Scientific Papers. Series B. Horticulture, Vol. LXIV, no.1:163-168.

[10]Partal, E., Paraschivu, M., 2020, Results regarding the effect of crop rotation and fertilization on the yield and qualities at wheat and maize in South of Romania, Agricultural Sciences & Veterinary Medicine University, Bucharest, Scientific Papers. Series A. Agronomy, Vol. LXIII, no.2: 184-189.

[11]Paraschivu, M., Cotuna, O., Paraschivu, M., Durau, C.C., Damianov, S., 2015, Assesment of *Drechslera tritici repentis (Died.) Shoemaker* attack on winter wheat in different soil and climate conditions in Romania, European Biotecnology Congress the 20th August 2015, Bucharest, Journal of Biotechnology, Vol. 208:S113.

[12]Rosculete, C.A., Bonciu, E., Rosculete, E., Olaru, L.A., 2019, Determination of the Environmental Pollution Potential of Some Herbicides by the Assessment of Cytotoxic and Genotoxic Effects on *Allium cepa*, Int. J. Environ. Res. Public Health, 16(1):75.

[13]Sarateanu, V., Durau, C.C., Cotuna, O., Rechitean, D., 2016, Influence of organic fertilisation on the vegetation sward of *Trisetum flavescens (L.) P. Beauv*. grassland from temperate deciduous forest area (Case Study), Nano, Bio and Green - technologies for a Sustainable future Conference proceedings, SGEM, Vol. 3: 277-283.

[14]Tamba-Berehoiu, R., 2015, Food Chemistry (Chimia alimentului), vol. 1, Ștef Publishing House, Iași, pp. 63-84.

[15]Valdivia-Nájar, C.G., Martín-Belloso, O., Soliva-Fortuny, R., 2018, Impact of pulsed light treatments and storage time on the texture quality of fresh-cut tomatoes, Innov. Food Sci. Emerg. Technol., Vol. 45: 29-35.

[16]Vizireanu, C., 2003, Preservation processes used in the food industry, AGIR, 3: 45-49.

[17]Wang, Y., Zhang, M., Mujumdar, A. S., Mothibe, K. J., 2012, Microwave assisted pulse spouted bed freeze-drying of stem lettuce slices - effect on product quality, Food and Bioprocess Technology, Vol. 6(12): 3530-3543.

[18]Won, M.Y., Lee, S.J., Min, S.C., 2017, Mandarin preservation by microwave-powered cold plasma treatment, Innovative Food Science & Emerging Technologies, Vol. 39: 25-32.

[19]Wray, D., Ramaswamy, H.S., 2015a, Development of a microwave vacuum based dehydration technique for fresh and microwave osmotic (MWODS) pretreated whole cranberries (*Vaccinium macrocarpon*), Drying Technology, Vol. 33(7): 796-807.

[20]Wray, D., Ramaswamy, H.S., 2015b, Novel concepts in microwave drying of foods, Drying Technology, Vol. 33(7): 769-783.