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THEORETICAL RESEARCH ON THE TRANSFORMATIONS, LOSSES AND IMPAIRMENTS UNDERGONE BY SOME FOREST FRUITS DURING THEIR VALORIZATION PROCESS IN A FRESH STATE

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Abstract: *The paper presents some theoretical aspects regarding the impairments which forests fruits undergo, while being in a fresh state. Since berries are still living organisms, even after the interruption of the vegetative state, and since they are rich in sugar, vitamins, mineral substances and have a high water content (85-95%), they are a propitious environment and present favourable conditions to the development of microorganisms, which leads to their degradation. The only procedures that would prevent, to some extent, the impairment of the fruits are the conservation methods such as: congelation, drying, dehydration, lyophilization, the application of some thermal treatments.*
Keywords: *transformations, losses, impairments, forest fruits.*

1. INTRODUCTION

Forest fruits are part of the group of excessively perishable fruits and they include the following species: strawberries, blueberries, blackberries, raspberries, black, white, red currants, gooseberries etc. They are characterized by low structural-textural firmness, delicate tissues, thin skin, high water content. They are very sensitive to high temperatures and pressures that occur during harvesting, handling, storage.
Harvesting also implies pre-sorting the fruits. Little baskets of 0.5-1.0 kg in plastic material or little cases that comprise amounts of 4-5 kg fruits are used as packages. In order to maintain quality, the batches of fruits are immediately pre-cooled, resorting to mobile aggregates or frigorific transportation vehicles. The packages shall be carefully handled, avoiding to harm the fruits. Temporary storage is performed at the temperature of 0ºC and it may last for 1-6 days.
Quality maintenance is ensured if the frigorific chain is used throughout the circuit from the producer to the consumer.

- ***Strawberries*** are harvested according to their destination: for the consumption at a great distance from the place of production, the pigmentation covers 70% of the fruit surface. Packages shall be carefully handled so as not to depreciate fruits and not to require further sorting at the storage spaces.

At the processing and recovery centres, their stay lasts for a short time, as the losses increase: within 4-6 hours, the losses are of 2%, and after 17 hours, they reach 3.2%.
Long-distance transport is done by means of isothermal or frigorific transportation vehicles, which may be cooled by ice, by using the refrigeration aggregate or by combining these two methods.
In order to maintain their quality, the structural-textural firmness, the specific gloss, the taste characteristics and, in general, the nutritional value, they are stored under 0ºC temperature and 85-90% relative humidity. Under these conditions, after 6 days, total losses reach about 13%.

- ***Red, white and black currants*** have a recovery period covering about 10 days. The uniformly maturated bunches with grapes of a colour characteristic to their variety are appreciated to be of higher quality. Fruit quality maintenance requires the use of the frigorific chain from their harvesting. The recommended temperature for storage is of 0ºC, and the relative humidity of 90%, the quality maintenance duration lasting, under these conditions, for 2-3 weeks.
- ***Raspberries and black berries*** are valorised at the end of June. In order to maintain their quality, the frigorific chain shall be used from their harvesting. Since they have a high degree of perishability, they shall be packed in plastic baskets with a capacity of 0.250-0.500 kg. The temporary storage, which may last for 2-3 days, shall be done under -0.5…-0ºC temperature and 85-90% relative humidity conditions.
- ***Gooseberries*** shall be carefully handled, being packed in plastic baskets. During their transportation, as

well as during their transit or temporary storage, the temperature of 0ºC and the relative humidity of 90% shall be ensured, which conditions allow quality maintenance for 2-3 weeks.

- ***Blueberries*** are valorised under similar conditions to the species in this group. In order to maintain the quality for a 2-week period, environmental conditions with a temperature of -0.5…-0ºC and relative humidity of 90-95% are used.

2. MATERIAL AND METHOD

2.1. Losses occurring in the fresh forest fruit valorization process

Forest fruits, as living organisms, are subjected to impairment and loss, as a result of various external factors and microorganisms. Their impairment to a greater degree makes the products no longer usable and hence "their death" occurs.

According to their nature, the losses and impairments may be:

- weight losses, due to the normal course of the metabolic processes (transpiration, respiration);
- qualitative impairments, due to the normal or abnormal course of the physiological processes, to the action of the microorganisms etc. which manifest themselves by modifications in colour, firmness, taste, occurrence of rot etc.

1. Weight losses

During their storage, a decrease in the weight of the fruit, known as weight loss, occurs. This phenomenon is the result of a normal process, characteristic of horticultural products, which are living organisms, and it is due to:

- reduction in the content of dry matter;
- water loss by transpiration.

Fruit weight losses are influenced by the biological properties of these products and hence they differ according to each species and variety.

Species characteristics determine the extent of the weight losses, to wit for the products with a higher degree of perishability, such as: strawberries, blackberries, raspberries etc. the value of such decreases is higher, compared to the species with a lower degree of perishability, such as: apples, pears, quinces etc.

Fruit size is another factor that influences weight losses.

Storage conditions are decisive factors for diminishing fruit weight losses. Relative humidity, temperature, air speed etc. influence the pressure of water vapour in the environment, increasing or decreasing the saturation deficit in water vapour in the air, which favours or inhibits the loss of water from fruits.

2. Qualitative impairments

During the preservation of fruits, their qualitative value diminishes, due to the metabolism processes, to the action of microorganisms etc. Therefore, changes in colour, firmness, taste, aroma etc. occur.

The qualitative impairments may be grouped as follows:

- qualitative downgrades, which represent the passage of products from a higher quality to a lower one;
- decrease by alteration (downgrading) based on the fact that the products become unsuitable for fresh consumption; however, they can be used in the alcohol industry, in the form of waste in animal nutrition or of fertilizers.

Qualitative impairment is a normal process during the storage of fruits; however, the way of manifestation and their size are conditioned by the cultivation and capitalization technology resorted to.

Depending on the factors that produce them, the qualitative impairments may be due to the normal development of the metabolic processes, to the cryptogamic and physiological diseases, or to the accidents that may occur during the recovery process.

2.2. Qualitative impairments due to the normal course of metabolic processes

During the preservation of fruits, due to the metabolic processes that take place, their impairment occurs. This consists in: shrivelling, change in colour, in structural-textural firmness, in taste, aroma, nutritional value.

- *Shrivelling* (wrinkling, withering) is due to the loss of water from the fruit tissues, as a result of the transpiration process.

The prevention of shrivelling is achieved by preserving the fruits under optimal conditions of temperature and relative humidity.

- *Fruit colour modification* occurs frequently during the storage and is mainly due to the changes that the chlorophyll, carotenoid and flavonic pigments undergo.

The inhibition of fruit colour change may be achieved by keeping these products in cold stores (at the optimal temperature for the respective variety and species) or in a controlled atmosphere. Under these circumstances, at

the end of the storage period, the products retain their characteristic colour, and the appearance of an abnormal colour is avoided.

- *Modification in the structural-textural firmness* of the fruits during their storage, in the sense of excessive,

diminution, is a quality depreciation. In the event of preserving the horticultural products under inappropriate conditions (at higher temperatures), the structural-textural firmness rapidly decreases.

The maintenance of the structural-textural firmness of the fruits is achieved by keeping them under optimal conditions of temperature, humidity and gaseous composition.

- *The modification in the taste and aroma* of the fruits during the storage-capitalization process is normal and occurs both in a positive and in a negative sense. In a positive sense, these modifications take place in the direction of the formation of the characteristic taste and aroma. The negative modifications consist in the alteration of the taste and of the aroma. *The avoidance of taste alteration* is achieved by keeping the products under optimal conditions.
- *The modification in the nutritional value* of the fruit occurs as a result of the oxidation of the substances important for nutrition, such as: carbohydrates, organic acids, vitamins, protein substances etc.

The decrease in the nutritional value of the fruits is influenced by the following factors:

- the biological properties of the products. For instance, in the products with high respiratory intensity, the nutritional value decreases faster, compared to the products with a slower metabolism;
- storage time (shelf life). The longer the time of storage, the lower the value of the main chemical components and therefore the value of the nutritional value of the fruits;
- the storage conditions are an essential factor in maintaining the nutritional value of the stored products.

This way, in the warehouses with controlled atmosphere, a reduction of the metabolic intensity by 40-60% occurs, and the products kept under these conditions maintain better their quality.

In the improvised warehouses, the optimal storage conditions are difficult to achieve and, consequently, the fruits undergo a significant diminution of their nutritional value.

2.3. Qualitative impairments caused by microorganisms and physiological diseases

- *Microorganisms* are one of the main causes that determine the qualitative impairment of the fruit.

Depending on the nature of the pathogens, the impairments can be caused by viruses (viroses), bacteria (bacterioses), fungi (mycoses) etc.

Product infestation occurs during product handling or storage. The microorganisms penetrate through:

- stomata or lenticels;
- wounds caused by blows or pests;
- perforation of the epidermis.

- *The transmission of physiological diseases* from one product to another is achieved either through direct contact or through the spores that are carried from one product to another by the stream of air or by the water used for washing. After the infestation, it takes a period of time, a period of incubation for the first symptoms of the disease to appear. These symptoms manifest as spots, dry or wet rots, necroses etc.

During the process of fruit capitalization, several impairments caused by the physiological diseases may occur. The cause of these impairments is the abnormal development of the metabolic processes in fruits. The form of manifestation is very diverse: superficial spots, browning of internal tissues, areas with glassiness etc.

Some physiological diseases affect only the outer appearance of the fruits, while others completely depreciate the products.

Regardless of the form of manifestation or degree of extension, all physiological diseases favour the infestation of fruits by microorganisms and thus the faster impairment of the products.

- *Physiological diseases specific to some forest fruits*

1. Diseases of the strawberry

- ✓ *Powdery mildew of the strawberry* caused by the fungus *Sphaerotheca macularis*

Powdery mildew is one of the most damaging diseases for the strawberry crop. It frequently attacks the strawberry plantations with sensitive varieties to this pathogen, where the damages are of economic importance.

Figure 2.1.: Powdery mildew of the strawberry

Symptoms: the fungus attacks the leaves, the petioles, the flower peduncles and the fruit. On the fungus, on both sides, more frequently on the lower one, a whitish felt forms from the mycelium and conidia of the fungus. On the upper side, the tissues over against the stains acquire a reddish colour. The leaflets of the attacked leaves turn to the upper face, taking the form of a teaspoon. The attack also manifests on the fruits, in all their stages of development, in the form of a floury felt. The attacked green fruits no longer develop, they remain small and deformed, while the ripe ones are inferior in quality.
Pathogen: the globular peritecia, with numerous simple, flexible, long, light-brown appendices, containing a single avoid asca, with 8 ellipsoidal, unicellular, colourless ascopores.
Source of infection: the vegetal residues of the plants attacked by *Sphaerotheca macularis*.
Favourable conditions: the disease occurs in hot summers, with humid nights or on long foggy mornings.
Transmission-spread: during the vegetation period, the fungus spreads through the spores; and, from one year to another, through the mycelium of resistance and the peritecia on the attacked vegetal remains. In the autumn, on the underside of the leaves, small black spots appear, the peritecia, as a form of resistance.
Prophylaxis and therapy: it is recommended to rotate the crops and to avoid, in the crop rotation system, the solanaceae; to disinfect the soil in case of monoculture or in the risk areas, to use virgin soils, not cultivated for one or two years; to cultivate the strawberry annually or biennially; to use healthy planting material.

- ✓ *Grey rot* produced by the fungus *Botrytis cinerea*

It is one of the most widespread diseases in the strawberry which, depending on the humidity conditions, can cause significant losses of fruit (10-90 %).

Figure 2.2.: Grey rot

Symptoms: the attack manifests itself on all aerial organs of the plant, but more frequently and with the most damaging effect on flowers and fruits. The attacked fruits turn brown and eventually completely rot and are not edible. On their surface, under conditions of high humidity, a grey coating of conidiophores and fungal condidia appears. The massive attack is noticeable in the flowering phase of the strawberry; when brown spots develop quite rapidly on the attacked organs.
Pathogen: the conidiophores are filamentous, long, septated, olive at the basis, colourless to the top, branched in the upper portion. The conidia are ovoid, slightly yellowish.
Source of infection: the dry leaves and the remains of the plants attacked by the grey rot.
Propitious conditions: high humidity of the air, close to the dew-point value.
Transmission-spread: during the vegetation period, the disease is transmitted through the spores disseminated by means of raindrops, wind, man etc., and, from one year to another, through the resistance organs.
Prophylaxis and therapy: it is recommended to destroy the weeds, to eliminate the excess water from the plantation, to plant at greater distances.

2. Diseases of the raspberry

- ✓ *Grey rot* produced by the fungus *Botrytis cinerea*

Figure 2.3.: Grey rot

Symptoms: the flowers turn yellow and gradually covered with a grey felt. The attacked fruits turn dark, cover themselves with the same grey or whitish felt, and begin to rot. An earlier attack on fruits causes their mummification and they remain attached to the receptacle. In the rainy years, the attack of the rot also manifests on the stems, by the appearance of light-brown spots.
Pathogen: the disease attacks, most frequently, the blackberry flowers and fruits. The fungus winters in the form of sclerotic or mycelium of resistance in the plant remains. In early spring, the mycelium becomes active and forms filamentous, long, septated conidiophores, olive at the base, colourless to the top, branched in the upper part. An impressive number of microscopic spores-ovoid, slightly yellowish conidia develop in the conidiophores. The conidia are spread by the wind throughout the plantation, landing on flowers and fruits. Here they sprout in the presence of humidity.
Source of infection: vegetal remains of infected plants.
Propitious conditions: air humidity of 80-95 % and temperature between 20…27℃, closed space with no air circulation (stagnation of water on the surface of the plant).
Transmission-spread: during the vegetation period, the pathogen propagates through the conidia carried by the wind; and, from one year to another, through the mycelium of resistance (sclerotia) on the organs of the attacked plants.
Prophylaxis and therapy: when applying the treatments, special attention shall be paid to the producer's recommendations on concentration and application rules. When establishing the plantations, a high-quality planting material shall be purchased. It is also recommended to destroy the weeds and to eliminate the excess water from the plantation, to disinfect the soil in case of monoculture or in risk areas, to use virgin, uncultivated soils for one or two years; annual or biennial culture. In the ordinary years, 2-3 treatments are made; and in the rainy ones, 3-4 with botrycide products.

3. Diseases of the blackberry

- ✓ *Grey rot* produced by the fungus *Botrytis cinerea*

Figure 2.4.: Grey rot

Symptoms: the flowers attacked by the fungus *Botrytis cinerea* and gradually convered with a grey felt, the fruits turn dark, cover themselves with the same grey or whitish felt, and begin to rot. An earlier attack on fruits causes their mummification and they remain attached to the receptacle. In the rainy years, the attack of the rot also manifests on the stems, by the appearance of light-brown spots. The attack is sometimes confused with the one produced by *Didymella applanata*.
Pathogen: the fungus *Botrytis cinerea* attacks, most frequently, the blackberry flowers and fruits. The fungus winters in the form of sclerotic or mycelium of resistance in the plant remains. In early spring, the mycelium becomes active and forms filamentous, long, septated conidiophores, olive at the base, colourless to the top, branched in the upper part. An impressive number of microscopic spores-ovoid, slightly yellowish conidia

develop in the conidiophores. The conidia are spread by the wind throughout the plantation, landing on flowers and fruits. Here they sprout in the presence of humidity.
Source of infection: infected vegetal remains.
Propitious conditions: increased air humidity (80-95%), air temperature between 20…27℃, closed space with no air circulation (stagnation of water on the surface of the plant), weed growth on the plantations, too high a density of the plants.
Transmission-spread: during the vegetation period, the pathogen propagates through the conidia carried by the wind; and, from one year to another, through the mycelium of resistance (sclerotia) on the organs of the attacked plants.
Prophylaxis and therapy: to comply with the measures of crop hygiene in plantations. In the ordinary years, 2-3 treatments are made; and in the rainy ones, 3-4 with botrycide products. When establishing the plantations, a high-quality planting material shall be purchased, produced in authorized grow houses or breeding grounds. It is also recommended to destroy the weeds and to eliminate the excess water from the plantation.

4. Diseases of gooseberry

- ✓ *Powdery mildew* produced by the fungus *Sphaerotheca mors-uvae*

It is easily noticeable in the currant and gooseberry plantations, producing considerable damage by early the early (July-August) of the bushes.
Symptoms: the fungus attacks the leaves, shoots and fruits. The attacked organs are covered, usually on their entire surface, by a fine, initially whitish-yellowish, then brown felt, as a result of the formation of the fungus peritecia.
The leaves remain small, wrinkle and fall early. The attacked shoots no longer develop, the fruit buds do not differentiate, which leads to a decrease in production. The fruits, under the conditions of a strong attack, may be attacked in all phases of development, especially towards ripening. Young fruits shrivel up and blacken, and the ripe ones crack and rot.

Figure 2.5.: Powdery mildew of gooseberry

Pathogen: the fungus *Sphaerotheca mors-uvae* attacks the leaves, shoots and fruits. The first symptoms appear in late spring, in the form of a felt, initially whitish-grey, which becomes brown and powdery in time, due to the formation of the conidia. Over time, the fungus forms specialized extensions of the talus (haus-torii) by which it penetrates in the attacked organs to suck the nutrients. Under optimal environmental conditions (at leat 70 % air humidity and temperatures of 20…25°C) the fungus spreads relatively quickly. At the end of the vegetation period, the fungus as a mycelium of resistance on the attacked plant.
Source of the infection: the affected parts of plants.
Propitious conditions: high air humidity and high temperatures.
Transmission-spread: during the summer, the fungus spores are spread by the wind.
Prophylaxis and therapy: planting healthy gooseberry varieties and hybrids, resistant to powdery mildew. Application of agro-phytotechnical measures and chemical treatments with fungicides, at the warning. The use of nitrogen fertilizers shall be avoided. The affected part of the plants must be cut off and destroyed.

5. Diseases of buckthorn

- ✓ *Endomycosis* on the buckthorn fruits

Figure 2.6.: Endomycosis on the buckthorn fruits

Symptoms: the disease manifests itself by the bleaching and thinning of the fruit parenchyma. In early August, The first symptoms of the disease appear. The skin of the attacked fruits, during harvesting or during rain and wind, cracks and their content drips down the branches. The infected fruits shrivel up and remain mummified. The fungus winters as mycelium of resistance in the bark of the branches, as well as in the mummified fruits; and, in the spring, it forms spores which generate the first infections on all the young organs of the trees. The endomycosis develops in July-August on the parts of the plant exposed to sunlight. The fungus parasitizes the fruits whih suffer from excess sun or temperature fluctuations. The buckthorn varieties whose fruits have very thin skin are the most susceptible to endomycosis. The attack on the nearly ripe fruits is favoured by the insect bites (eg lice) or wounds caused by hail or fungi, which are entrance gates for the infection.
Pathogen: is a fungus of the *Monilia* genus.
Source of infection: infected vegetal remains.
Propitious conditions: heavy rainfall and abundant dew.

6. Diseases of the rosehip

- ✓ *Rust* caused by Phragmidium tuberculatum

Rust is a disease caused by *Phragmidium* fungus and other relates species. The susceptibility to rust varies according to the variety, most varieties being resistant to this disease.

Figure 2.7.: Rust on the rosehip leaves and flowers

Symptoms: the rust manifests itself on leaves, flowers, shoots, on which the following symptoms appear in the spring:

- On the stems: large pustules of spores in the form of dust, bright, coloured in orange;
- On the upper side of the leaves: yellow spots, over against which, on the lower face, orange, circular pustules form. In late summer, the yellow pustules turn black, and the attacked leaves fall early. The attack on the leaves leads to their deformation. Towards autumn, the affected leaves fall prematurely, which leads to the premature defoliation of the bushes, which generates a poor maturation of the wood and an increased risk of its freezing in winter.

Pathogen: in spring, the hibernating mycelium of the fungus forms, on the back of the leaves, oval little cushions of orange equidiospores. On the shoots and petioles, several equids take shape, which thicken and deform the attacked organs. Upon dissemination, the equidiospores end up on other plants and form micelles on the latter, where uredospores dvelop, which resemble the equidiospores on the outside, but which, unlike them, are placed on a small foot. Over three weeks, the fungus teleutospores appear and form, on the underside of the leaves, a deposit of dark colours. The fungus winters in the stage of teleutospores in the fallen leaves or in the form of mycelium in the affected shoots.
Source of infection: vegetal remains (strongly affected leaves and shoots).

Propitious conditions: it manifests itself especially in the years with cold and humid springs.
Transmission-spread: the uredospores ensure the spread of the disease during the summer. The teleutospores are resistance spores and they survive through the winter.
Prophylaxis and therapy:

- *non-chemical control*: cultivating rust-resistant rosehip varieties; cutting and burning the attacked shoots to prevent the spread of spring spores; collecting and destroying the leaves fallen in autumn to reduce the number of spores. In case the rust is persistently annoying, the variety concerned must be replaced with another one, less susceptible to rust.
- *Chemical control*: the fungicides with tebuconazole and triticonazole as active substance are labelled for rust control.

3. CONCLUSIONS

- **Requirements for fruit storage**

The excessively perishable fruits, such as the berries, depend on certain storage parameters, there are storage durations beyond which the perishable products become unusable. Food storage requires the compliance with a number of conditions referring to:

- air temperature;
- air humidity;
- air purity (microbiological load and any kind of pollutants);
- composition of internal atmosphere;
- air distribution and ventilation at the product level;
- packing and placing the products in the cooled space;
- the degree of loading with products of the storage space;
- operation of the refrigeration installation (especially in terms of permanently correlating the frigorific power with the needed cold);
- hygiene throughout the product storage.

- **Modern methods of fruit storage**

Soft fruits are stored in refrigeration spaces with regular atmosphere (AR) or with controlled atmosphere (AC). Fruit storage in a normal atmosphere (AR) is achieved in refrigeration spaces where the air is not only cooled, but also humidified. The fruits should be cooled as soon as possible after harvesting, to the storage temperature; the sooner, the higher their perishability degree. The ideal fruit refrigeration chain starts right at the place of harvest. In this regard, worldwide there is a tendency to develop fruit pre-cooling stations precisely in the areas where they are grown. Table 3.1. shows the parameters of temperature and relative air humidity, as well as the permissible storage durations in a refrigerated state for soft fruits. The optimal storage conditions are the temperature between -0.5…0 °C and the relative air humidity of 90-95 %.

Table 3.1.: The optimal parameters for soft-fruit storage in a regular atmosphere (AR)

Product scientific name	**T of storage [ºC]**	**Air rel. humid. [%]**	**T of freezing [ºC]**	**Ethylene production**	**Susceptibility to ethylene**	**Storage duration**	**Obs. and beneficial conditions regarding controlled atmosphere [CA]**
Strawberry *(Fragaria L.)*	0	90-95	-0.8	low	low	7-10 days	5-10% O_2+15-20 CO_2
Raspberry *(Rubus idaeus L.)*	-0.5…0	90-95	-0.9	low	low	3-6 days	5-10% O_2+15-20 CO_2
Blackberry *(Rubus sect. Rubus)*	-0.5…0	90-95	-0.8	low	low	3-6 days	5-10% O_2+15-20 CO_2
Red currants *(Ribes rubrum L.,)*	0-1	95	-0.9	low	low	2.5 weeks	2% O_2 + 18-20% CO_2
Black currants *(Ribes*	0-2	95	-0.9	low	low	1.5 weeks	-

nigrum L.)							
Goose-berries ***(Ribes uva-crispa L.)***	0-1	95	-0.9	low	low	6-8 weeks	1.5% O_2 + 10-15 % CO_2
Sorb tree and fruit ***(Sorbus domestica) Ell.)***	0-2	95	-0.9	low	low	1.5 weeks	-
Sea buck-thorn ***(Hyppophae rhamnoides)***	0	95	-0.9	low	low	up to 5 days	-

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