Walnuts Respiration (Juglans regia L) during storage

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Abstract

Introduction. The respiratory rates of English walnut (*Juglans Regia L.*) and factors that may affect it were studied.

Materials and methods. The walnut respiration intensity was determined by the confined atmosphere process. It was used the CO_2 capture method removed from the product with alkaline solution. To assess the influence of temperature on the respiration intensity of unshelled walnuts and walnut kernel, they were kept under four temperature regimes: 6±2, 18±2, 30±2 and 50±2 °C.

Results and discussion. Respiration is one of the oxido-reduction processes that can lead to the oxidative degradation of walnut lipids, respectively their qualitative degradation.

Walnut moisture content is one of the main factors influencing the respiratory rate. Initial respiration intensity of the walnuts is high, but falls sharply in the first 15 days of storage. This decrease being related to the reduction in walnut moisture. The respiration intensity of walnuts decreases slightly after 15 days of storage.

There was established a relationship between the respiration intensity and environmental temperatures. The maximum of respiratory rates were at 30 °C.

Respiration intensity of the walnut kernel is greater than that of the unshelled walnuts, the shell serving as a barrier to the direct contact between the kernel lipids and oxygen. The walnut kernel respiration intensity increaces from 5 mg to 23 CO_2/kg·h at an increase of temperature from 5 to 30 °C. At a further increase of temperature to 60 °C the respiration intensity reduces to 15 CO_2/ kg·h. The unshelled walnut respiration intensity increaces from 5 mg to 17 CO_2/ kg·h at an increase of temperature from 5 to 30 °C. At a further increase of temperature to 60 °C the respiration intensity reduces to 12 CO_2/ kg·h.

It is noted that the walnats lipids acidity index correlates with the storage temperature, but more pronounced in the case of the kernel and slower for unshelled walnuts. The acidity index of the lipids of and unshelled walnut and kernel doesn't change at an increase of temperature from 5 to 15 °C and it is approximately 0.35 mg NaOH/g prod. At a further increase of temperature to 40 °C the lipid acidity index increases to 0.8 NaOH/g prod (for the kernel) and 1.1 (for unpurified walnuts). At a further increase of temperature to 60 °C, the lipid acidity index reduces to 0.6 NaOH/g prod.

Conclusions. Walnut respiration may be limited by low temperatures storage. It is therefore important to ensure storage stability by complying with the limit values for the water content of walnuts. Fruit morphologiacal state also affects the respiration intensity, this parameter being greater for kernels than for unshelled fruits, the differcence being due to shell which servs as a barrier to the direct contact between the kernel and the oxygen.

Introduction

Worldwide walnuts are recommended as a constituent of balanced human nutrition. The high protein and oil contents of the kernels of Juglans regia L. (Juglandacea) make this fruit indispensable for human nutrition [13]. Walnuts contain about 65% lipids with a very high level of unsaturated fatty acids making fruits prone to lipid degradation.

In Moldova, walnuts have been and continue to be a valuable agricultural product. Moldova is favorably positioned from a geographical point of view, on both climatic and pedological conditions for the cultivation of nuts [1], being among the top ten kernel and unshelled walnut producers in the world [2], The volume of production reaching about 30 thousand tons per year [3]. Since the year 2000 the walnut culture has known a substantial evolution in the Republic of Moldova, greatly sustained by the joint efforts of some active promoters and of the Government financial assistance. [12]

Storage of fresh harvested walnut for a certain period of time - is one of the most important processes [4], being paramount importance in quality maintenance. Walnut fruits may be stored either in-shell or shelled. A general belief is that fruits are better preserved when stored in-shell than after shelling. However, the former method has two disadvantages. The first is that in-shell nuts occupy a far greater storage volume. The second is that a larger percentage of nuts are damaged mechanically during shelling since the in-shell nuts are stored at low moisture content (m.c.) to prevent degradation during storage. The higher the level of broken nuts, the lower is the deterioration percentage of the seeds [18].

The main walnut quality concerns are rancidity, mold growth, insect infestation, and stale flavor. Earlier, Prabhakar (1977) reported that development of undesirable odours occurred in walnut kernels when stored at higher humidity and free fatty acid content increased with increase in temperature and storage period [14].

Changes of the chemical compounds of walnuts is carried out in several ways, but the basic direction is respiration, which in fact presents a range of biochemical oxidation - reduction reactions.

Respiration is one of the oxido-reduction processes that can lead to the oxidative degradation of walnut lipids, respectively their qualitative degradation.

In spite of having been removed from the tree, walnuts remain as living organs after harvest. They are living organs in which respiration processes predominate, because their supply of new nutrients has been cut off by separation from the parent plant. Throughout respiration, product nutrients (carbohydrates or lipids) are broken down to their constituent parts to produce energy to run cellular processes, thus keeping the cells and organism alive.

As respiration continues, compounds that affect plant flavor, sweetness, weight, turgor (water content), and nutritional value are lost [11]. It is obvious that the rate or intensity of respiration depends on the chemical composition of the walnut kernel, the degree of maturation and other external factors such as temperature, oxygen concentration in the air, etc [5–6].

There is little the postharvest physiologist can do to alter the internal factors affecting respiration of harvested commodities, since they are largely a function of the commodity itself once harvested. However, a major part of postharvest technology is devoted to reducing respiration and other metabolic reactions associated with quality retention by manipulating the external environment.

Without a doubt, the most important factor affecting postharvest life is temperature. This is because temperature has a profound affect on the rates of biological reactions, eg., metabolism and respiration. Over the physiological range of most crops, ie., 0 to 30 °C (32 to 86 °F), increased temperatures cause an exponential rise in respiration. The Van't Hoff Rule states that the velocity of a biological reaction increases 2 to 3-fold for every 10 °C (18 °F) rise in temperature [15–17]. Additional information on respiration rates at different temperature levels is needed for the solution of practical problems concerned with storage and transportation of fresh.

For this reason, the purpose of this study was to investigate the walnuts respiration intensity, as well as its dependence on the morphological state of stored fruits (nuts in shell or kernel) and on the temperature of the storage medium.

Materials and methods

Materials

Walnult fruits, variety Calarasi, were collected from local walnut plantation, Iargara, Moldova. All chemicals used for experiments were at least analytical grade.

Sample preparation

Each sample was prepared for the experiment by first eliminating unsound or injured specimens.The sample was then divided into two or more weighed lots for the measurement of the rate of respiration at different temperatures. After weighing, each lot of fruit was kept at the temperature at which it was desired to measure the rate of respiration for several hours or overnight before starting the experiment

Method

To assess the intensity of respiration, as well as the influence of temperature on it, were used both nuts in shell and kernel.

To assess the influence of temperature on the respiration intensity of unshelled walnuts and kernel, they were kept under four temperature regimes: 6 ± 2^0C, 18 ± 2^0C, 30 ± 2^0C and 50 ± 2^0C. The respiration intensity was determined by the confined atmosphere process as recommended by Boysen -Jensen [7]. The CO_2 capture method removed from the product with alkaline solution is the most perfect and most commonly used in scientific work.

The apparatus used in the measurement of respiration intensity consists of a desiccator provided with a vertical tube filled with granulated sodium hydroxyde. The air entering the desiccator was first drawn through the tube to free it from carbon dioxid. The dessicator bottom was supplied with a Petri dish containing sodium hydroxide solution, this way the eliminated CO2 through respiration processes is capted by this solution. Then, the method of double titration was used, in which phenolphthalein and methyl orange are employed successively.

Normal hydrochloric acid was added to the alkaline solution, in presence of phenolphthalein, until it was colorless. Methyl orange was then added and the titration finished.

Results and discussion

Respiration is affected by a number of environmental factors such as light, temperature, chemical stress, pathogen attack, the action of radiation, the action of humidity, etc. The most important post-harvesting factors are temperature, atmospheric composition and physiological state.

The process of respiration of the fruit is relatively large topic discussed in the scientific literature and specialist, but the studies on Juglans Regia nuts are very limited [8-10], and on the nuts grown in Modova are totally lacking. The evolution of respiration intensity of fresh nuts (directly after harvesting) stored at 20 °C was monitored for 60 days from storage. Following the conventional method of expressing the degree of respiratory activity, the results of these experiments are reported in terms of carbon dioxide production.

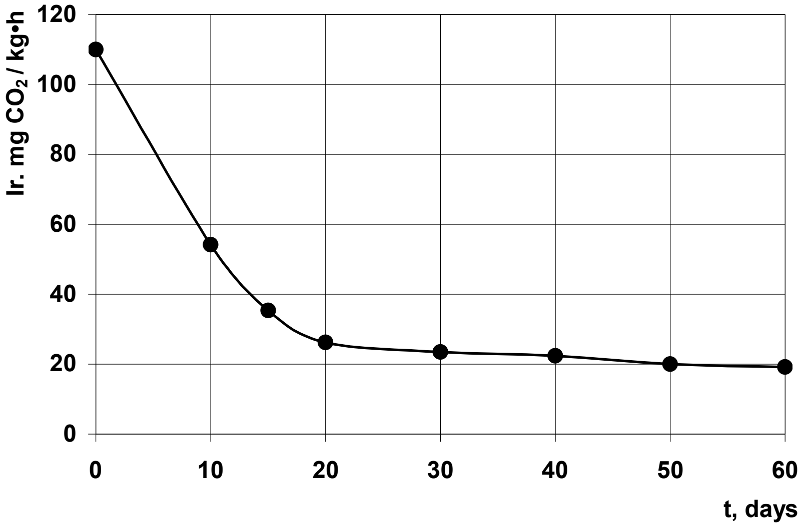

Figure 1. Evolution of respiration intensity of fresh harvested walnuts

Initial respiration intensity of the walnuts is quite high, but falls sharply in the first 15 days of storage. In the following period, the respiration rate continues to decrease at a much lower rate. This decrease is likely (at least in part) related to the reduction in walnut moisture from 20% for fresh walnuts to 12% after 15 days and 8% - towards the end of storage.

In order to identify the impact of the ambient temperature and the walnuts morphological state on the respiration process, the respiration intensity of unshelled nuts (dried up to W = 8%) and of the walnut kernel at different temperatures was studied. The results obtained are shown in Figures 2 and 3.

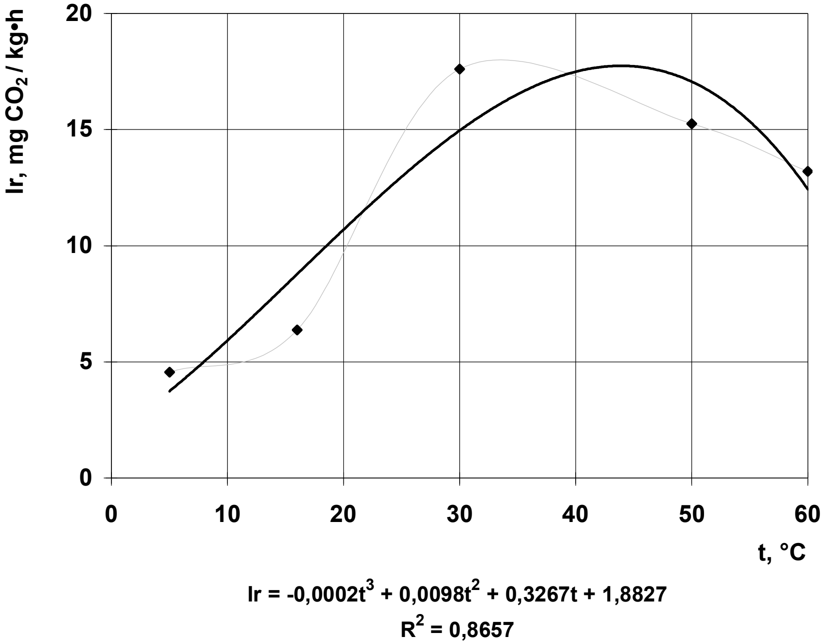

Figure 2. Dependence of the unshelled walnut respiration intensity of the ambient temperature

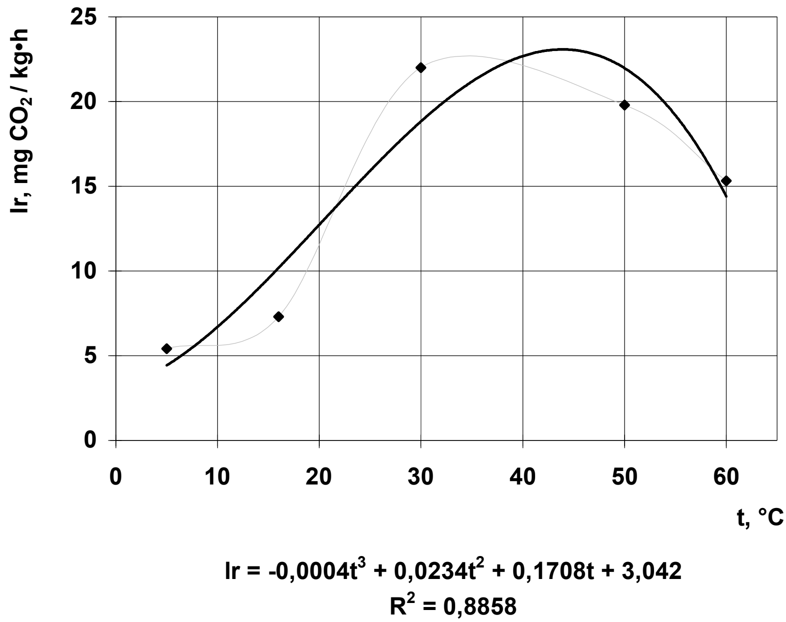

Figure 3. Dependence of the walnut kernel respiration intensity of the ambient temperature

The obtained data reflects the respiration intensity of unshelled walnuts. Maximum values of this indicator were obtained by storing walnuts at 30 °C (17.6 mg CO_2/kg·h), after t> 40 °C the intensity of walnuts tends to decrease.

It has been found that the respiration intensity of the walnut kernel is greater than that of the unshelled fruits. It is worth mentioning that this differcence is probably due to shell which servs as a barrier to the direct contact between the kernel and the oxygen. When shelled, walnut lipids react with atmospheric oxygen which enters into an addition reaction with unsaturated fatty acids through the simultaneous assistance of light, heat and certain fat companion substances. Rancidity caused by oxidative fat cleavage is particularly noticeable in the case of shelled walnuts, because the shelling process results to a certain degree in exposure to atmospheric oxygen.

From the figures and presented equations we deduce that the respiration rate of walnuts depends largely on the temperature of their storage. Respiration intensity in both cases (shelled and unshelled fruits) increases slowly with increasing temperature from 4 to 20 ^{o}C, then suddenly rises to the maximum value at temperatures of about 30–40 ^{o}C, followed by a decrease in respiration intensity at higher temperatures.

Increased respiration intensity in the temperature range 20–37 ^{o}C can be explained by increasing the activity of lipases that induce lipid hydrolysis processes and increase the amount of substrate (fatty acids) for respiratory processes. Endogenous lipids in the walnut kernel hydrolyze lipids to glycerin and free fatty acids, which are then oxidized to produce the energy required for plant biological activity. At temperatures above 40^{o}C enzymes are denatured and inactivated.

Hence, lipid hydrolysis was mentioned, the dependence of the acidity index (expressing the free fatty acid content) of lipids of walnuts held at different temperatures was studied. The obtained results are shown in Figure 4.

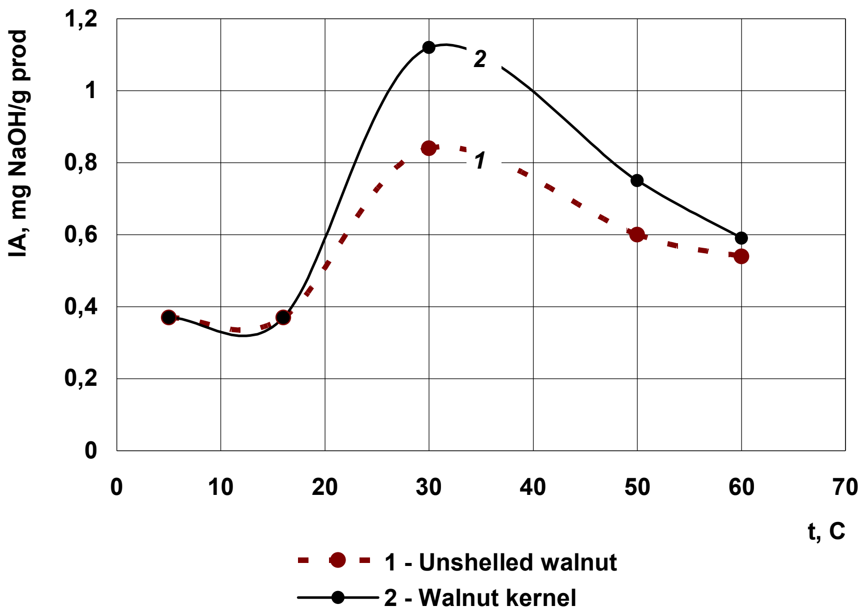

Figure 4. Dependence of acidity index of unshelled walnut and kernel lipids of storage temperature

It is noted that the acidity index correlates with the storage temperature, but more pronounced in the case of the kernel and slower for unshelled walnuts.

Conclusion

In walnuts (particularly when fresh), metabolic processes continue even after harvesting. They absorb oxygen and excrete carbon dioxide (CO_2).

Initial respiratory intensity of walnuts is quite high, but drops sharply in the first 15 days of storage. This decrease is associated with the walnut moisture content, that is why it is therefore important to ensure storage stability by complying with the limit values for the water content of the walnut fruits.

A relationship has been established between respiration intensity and storage temperature, as the temperature increases product respiration rate increases sharply and at 30 °C reaches a maximum.

Storage conditions and fruits morphological state (shelled or unshelled fruits) affect respiration intensity, thus, reducing the rate of respiration is an important consideration in extending the postharvest life of walnut fruits and optimizing postharvest quality.

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