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# ASPARAGUS DRY SOLUBLE AND INSOLUBLE MATTER DURING STORAGE

*Summary.* Asparagus contains valuable biologically active substances that have antioxidant, fungitoxic and anticancer properties. The biochemical composition of asparagus depends on many agrotechnological and natural climatic factors. The purpose of this research is to establish the influence of cultivar properties of asparagus grown in Ukraine on the dynamics of the loss of dry matter during storage.

Fresh asparagus of the green Prius F1 and the purple Rosalie F1 cultivars were stored in an industrial refrigerator at a temperature of 2°C±0.5 and relative humidity of 95%±1.

The cultivars of different colours demonstrate differences in the quantitative indicators of respiratory intensity and the nature of the respiratory pattern. The dry matter content decreased linearly during storage. The dynamics of soluble solids content during storage was not linear. The cultivar specificity formed at the time of harvesting is preserved during the storage of asparagus, which confirms different suitability of cultivars for storage.

*Key words:* storage, green asparagus, purple asparagus, respiratory rate, dry matter, total soluble solids.

*Introduction.* Asparagus (Asparagus officinalis L.) is listed as “Kholodok likarskyi (asparagus)” in the State register of varieties and plants suitable for distribution in Ukraine. Despite the fact that it is one of the most delicious and expensive vegetable crops, asparagus is mainly known to Ukrainian consumers as an ornamental crop used for floristry. However, with the growing trend of healthy eating and the globalization of gastronomic preferences, asparagus is becoming part of Ukrainians’ diet. Asparagus contains the whole complex of valuable biologically active substances: dietary fibers, polyphenols, saponins and anthocyanins [7]. It has been proven that the dietary fibers of asparagus have antioxidant and antitumor effects [5, 28], effectively reduce the risk of diabetes [26]. Asparagus polyphenols demonstrate a fungitoxic effect [15]. Asparagus saponins inhibit the growth of cancer cells [24]. The active growth of demand for this gourmet vegetable in the HoReCa segment as well as the attractive profitability of asparagus stimulates farmers' interest in its cultivation. At present, asparagus is grown on 250 ... 300 hectares in Ukraine with an upward trend being observed before the war. Natural and climatic conditions and the soils of Ukraine are quite favourable for growing asparagus. Asparagus growing season in Ukraine is rather short – from the last decade of April until the beginning of June. This vegetable has about 200 cultivars, whereas only a few of them are used for food. As of April 2023, only 8 cultivars have been included in the register of cultivars of Ukraine: Backlim, Bacchus, Gijnlim, Grolim, Erasmus, Cumulus, Prius and Cygnus. All of them have been introduced by the Dutch companies: 5 cultivars belong to Bejo Zaden B.V., 2 to Limgroup B.V. and 1 to Asparagus Beheer B.V. Asparagus cultivars show high variability in agronomic and morpho-biochemical traits [18]. For this reason, the description of asparagus varieties grown using the same agricultural techniques and under the same conditions can provide useful information to market operators of fresh and processed asparagus.

*Recent research and publications analysis.* There are white, green, pink-green or purple cultivars of asparagus [7]. From a botanical point of view, white and green asparagus are the same plant. The stalks are white while growing underground, but when exposed to sunlight white asparagus turns green [27]. Cultivars of asparagus differ in the content of dry matter and the ratio of their component composition. Green asparagus contains a slightly lower amount of proteins but a higher amount of micronutrients, twice as much vitamin B, vitamin C and almost 200 times more vitamin A [1]. Purple cultivars of asparagus contain significantly higher amounts of anthocyanins than green ones [21]. The pool of dry matter in plants strongly depends on a number of factors: natural and climatic conditions of growing [20], cultivar properties [8] and agricultural techniques [4, 30, 31]. Dry matter accumulated during the growing season is the only source of metabolites at the post-harvest stage of life of the cropped asparagus shoots. As a result, the complex of dry matter undergoes changes during storage [13]. Therefore, the rate of dilatation of the pool of dry matter qualifies the speed of metabolic processes during storage.

Young shoots of asparagus 15-22 cm long, no thicker than 2 cm, are used for food. Since these are young parts of the plant, they have a very high level of respiratory metabolism. The intensity of respiration increases immediately after harvesting as a result of the wound stress from harvesting [12]. Harvested asparagus spoils quickly: the shelf life is 3–5 days at room temperature and 14–15 days in the refrigerator [18, 19]. Respiratory metabolism of asparagus can be limited mainly by lowering the storage temperature. The recommended conditions for commercial storage of asparagus are 0 to 2 °C with a relative humidity of 95 to 99%, which provides a shelf life of 14 to 21 days [11]. To extend the shelf life of asparagus, cold storage is supplemented with protective coating and the use of modified atmosphere [19, 23, 29]. Dry matter serves as a substrate for the respiration process [17]. The use of different substrates during respiration leads to the loss of reserve matter in tissues and the loss of palatability and nutritional value for a consumer [16]. Changes in the content of dry matter in asparagus are quite intense even when stored at 0°C and are fully correlated with the intensity of respiration [22].

*Purpose statement.* As can be seen from the above, the purpose of this article is to establish the influence of the cultivar properties of the asparagus grown in the conditions of Ukraine on the dynamics of the loss of dry matter during storage.

*Materials and methods of research.* Fresh asparagus stalks (Asparagus officinalis L.) were harvested from the «Shafran Liubymivskyi» farm in Kherson Region, Ukraine. The green cultivar Prius F1 and the purple cultivar Rosalie F1were used. After harvesting, the samples were rapidly cooled and transported to the laboratory at Dmytro Motornyi Tavria State Agrotechnological University within 4 hours. The asparagus stalks selected for the study were straight, undamaged, 1.6–2.0 cm in diameter and ~25 cm in length with closed bracts and no visible signs of injury.

Asparagus was stored in an industrial refrigerator at a temperature of 2°C±0.5 and relative air humidity 95%±1.

The intensity of respiration was determined by the amount of released carbon dioxide. The determination was carried out in the refrigeration conditions since the next day after starting of storage, as soon as asparagus stalks cooled down to the storage temperature (2°C). The content of dry matter was determined with the thermogravimetric method according to DSTU ISO 751, the content of dry soluble matter was determined with the refractometric method according to DSTU ISO 2173.

All tests were carried out in triplicate, and the data were exhibited as mean ± standard deviation.

*Results and discussion.* According to our research, the intensity of carbon dioxide release by asparagus during the storage period depends on the cultivar specificity (Fig. 1).

Green asparagus of Prius F1 cultivar showed a higher respiration rate during the entire storage period. However, the nature of respiratory metabolism was similar for both cultivars. Both cultivars reacted by decreasing the intensity of respiration immediately after cooling, which is natural [14]. The level of respiratory activity in general was close to what was described by other authors.

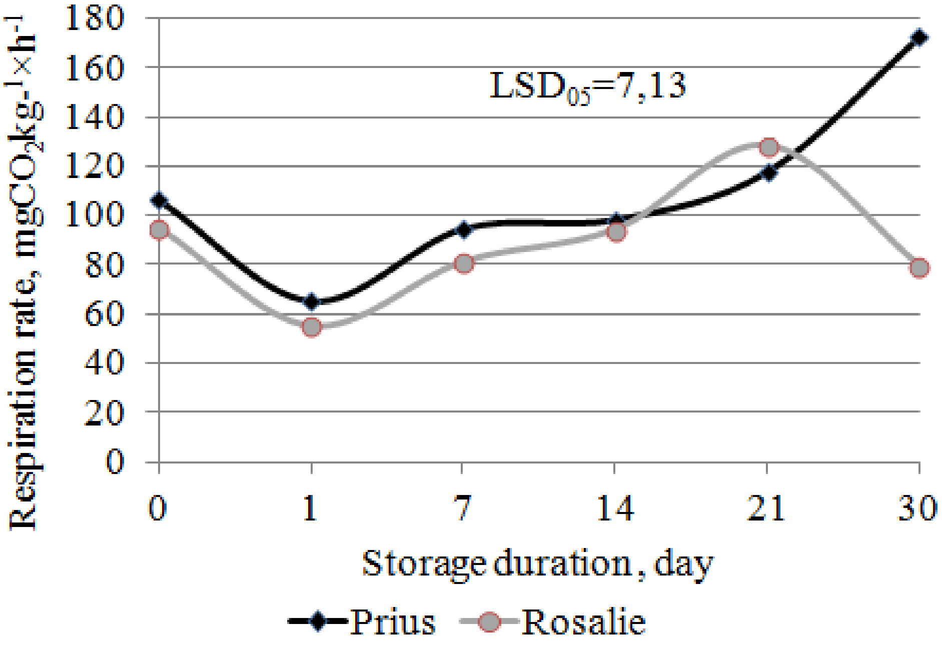


Figure 1. Respiration rate (fresh weight basis).

Anastasiadi et al. showed that the RR values steadily decreased during cold storage at 1°C with the highest value on the second day of storage of Gijnlim cultivar (122.6 mg $CO_2kg^{-1}$ $h^{-1}$) as compared with Guelph M. (57.1 mg $CO_2kg^{-1}$ $h^{-1}$) [2]. In contrast, Li et al. showed an increase in respiratory activity during the refrigerated storage of asparagus [9]. The research of Park demonstrated the similar respiratory pattern [13]. Asparagus stored at 2 °C, had decreased the level of respiration up to the 12th day of storage, and then respiration increased. At the same time, Guelph M cultivar showed some increase in respiration on the 16th day of storage with subsequent decrease [2]. Therefore, a decrease in respiration intensity after a short period of growth for Rosalie cultivar seems quite possible.

Asparagus is characterized by intensive moisture transpiration [6]. Therefore, at the initial stage of storage, there was a relative concentration of dry matter in both cultivars, and the loss of dry matter appears to be statistically insignificant. However, if recalculation with regard to the initial mass is done and the loss of dry matter due to respiration within 5% of the total mass loss is taken into account [3], the decrease of the dry matter (Fig. 2) seems to be natural, because in order to maintain the life of the plant in the postharvest period the constant catabolism of reserve matter takes place.

The rate of decrease in dry matter content reflects the intensity of biochemical reactions in asparagus during storage. A close inverse correlation (r=-0.97) is observed between respiratory metabolism and dry matter content for Prius cultivar.

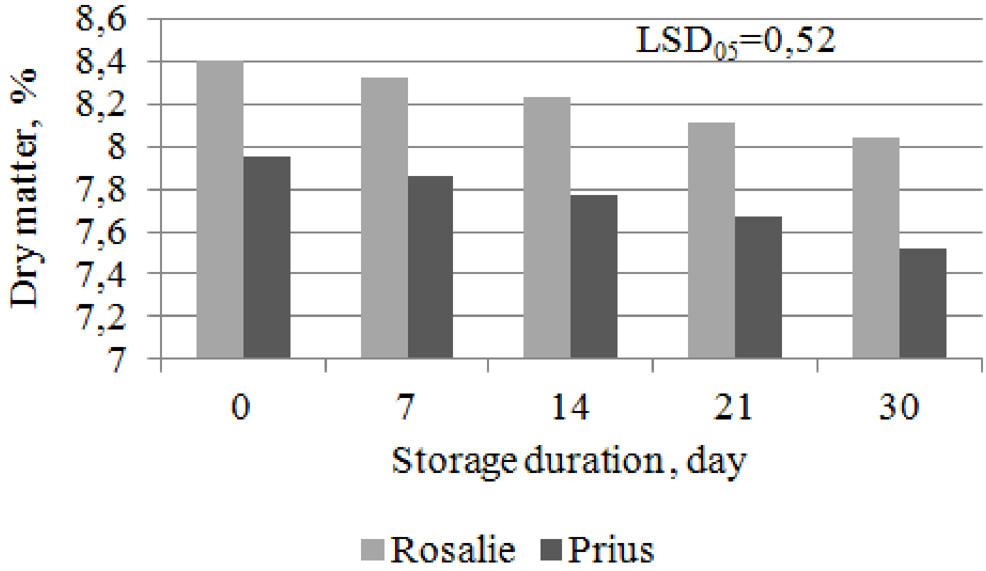


Figure 2. Dry matter content.

The change in the nature of respiratory activity at the final stage of storage reduced the correlation of these indicators for Rosalie cultivar to r=-0.59.

The percentage of dry soluble matter differs significantly from the content of dry matter in asparagus cultivars. If for Rosalie cultivar it is almost 87%, for Prius cultivar it is only 62%. Such a difference can be explained by the cultivar specificity of the biochemical composition. In general, for different cultivars of green asparagus, the content of dry soluble matter is reported to be about 5% with their content decreasing linearly during storage [25]. For our research, Rosalie cultivar contained 7.3±0.09 whereas Prius cultivar contained 4.9±0.08 ° Brix (Fig 3). During storage the content of dry soluble matter decreases, but the character is not linear. Similar results were obtained by Park [13]. A number of authors have described nonlinear changes in the content of simple saccharides during asparagus storage [10, 13, 22]. As simple saccharides are water-soluble, perhaps the resulting decrease in the total soluble solids content is related to restructuring of the saccharide complex.

*Conclusions.* Differences in the quantitative indicators of respiratory intensity and the nature of the respiratory pattern were observed in the investigated cultivars of different colours. Rosalie and Prius cultivars showed significantly different dry matter pool which decreased linearly during storage. The dry soluble matter of Rosalie cultivar is 87% of the dry matter pool, while Prius cultivar is only 62%. The dynamics of soluble solids content during storage was not linear. Thus essential cultivar specificity formed at the time of harvesting was preserved during storage of asparagus.

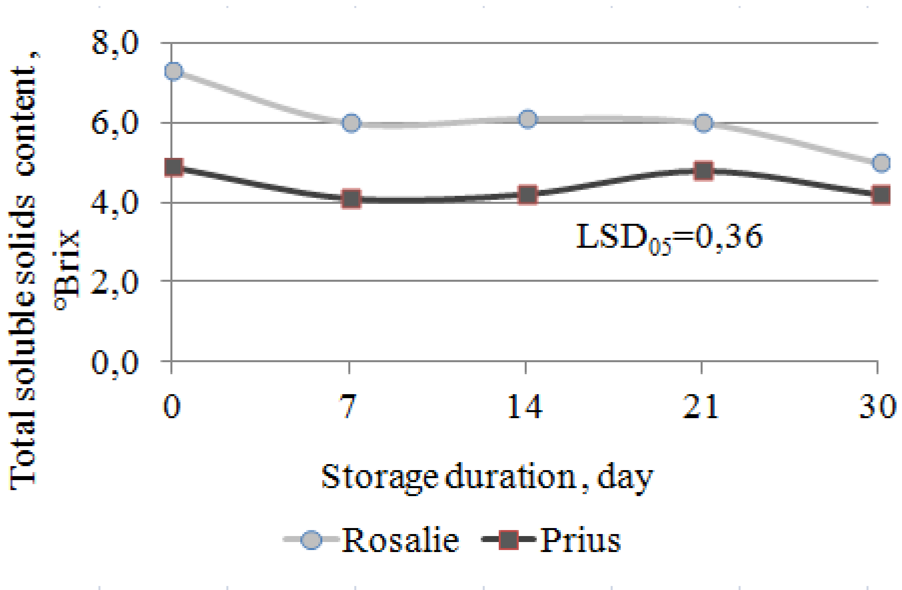


Figure 3. Total soluble solids content.

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## СУХІ РОЗЧИННІ І НЕРОЗЧИННІ РЕЧОВИНИ СПАРЖІ ПІД ЧАС ЗБЕРІГАННЯ

***Анотація***

Спаржа містить такі цінні біологічно активні речовини як харчові волокна, поліфеноли, сапоніни і антоціани. Ці фітонутрієнти володіють антиоксидантними, фунгітоксичними і протираковими властивостями, знижують ризики захворювання діабетом. Активне зростання попиту на цей делікатесний овоч в сегменті HoReCa та приваблива прибутковість спаржі стимулюють зацікавленість фермерів у її вирощуванні. Сорти спаржі сильно відрізняються за агрономічними та морфо-біохімічними ознаками. Вміст сухих речовин в рослинах сильно залежить від багатьох факторів: природно-кліматичних умов вирощування, сортових особливостей, агротехніки. Під час зберігання, сухі речовини залучаються в метаболічні процеси і їх пул виснажується. З цієї причини характеристика сортів спаржі, вирощених за однаковою агротехнікою та в однакових умовах, може надати корисну інформацію операторам ринку свіжої та переробленої спаржі.

Метою цієї статі було встановити вплив сортових особливостей спаржі вирощеної в умовах України на динаміку витрачання сухих речовин під час зберігання.

Свіжу спаржу зеленого сорту Prius F1 і фіолетового Розалі F1. зберігали в умовах промислового холодильника при температурі 2°С±0,5 та відносній вологості повітря 95%±1.

Встановлено, що досліджувані сорти різного забарвлення демонструють відмінності в кількісних показниках інтенсивності дихання та характері дихального процесу. Сорти Rosalie і Prius характеризуються суттєво різним пулом сухих речовин, котрий лінійно знижується під час зберігання. Сухі розчинні речовини сорту Rosalie становлять 87% пулу сухих речовин, а сорту Prius лише 62 %. Динаміка сухих розчинних речовин під час зберігання не була лінійною. Таким чином, суттєві сортова специфіка сформована на момент збору врожаю, зберігається при зберіганні спаржі, що підтверджує їх різну придатність до зберігання.

***Ключові слова*****:** зберігання, спаржа зелена, спаржа фіолетова, інтенсивність дихання, суха речовина, сухі розчинні речовини.