RESEARCH ON STORAGE AND PRESERVATION TECHNOLOGIES FOR RED AND WHITE CABBAGE

Alina Grigorita ARDELEAN[1#]

*University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea, Romania, e-mail: alina_popa_alina@yahoo.com

RESEARCH ARTICLE

Abstract

Depending on the preservation techniques, the late types of red and white cabbage offer themselves to storage for a specific amount of time. The storage period is shorter in improvised spaces with natural ventilation because the environment affects the metabolic activity of the cabbage heads, which manifests as a variety of depreciations, including weight loss, spoilage losses, and quality depreciations.

Keywords: white cabbage, red cabbage, storage, conditioning, losses.
#Corresponding author: Alina Grigorita Popa

INTRODUCTION

Since it is a plant that thrives in a temperate climate, cabbage has a wide range of cultivation areas both domestically and abroad. Its cultivation requirements are moderate in terms of temperature and light, but high when it comes to moisture and mineral nutrition. The nitrogen to potassium ratio needs to be 1:1.5 in order to produce a high-quality product. The lengthening of the vegetative period, the development of loose heads, and a decrease in their storage capacity, are all caused by an excess of nitrogen and a deficiency in potassium (R. Ciofu et al, 2004).

The complex chemical composition gives them food value, at the same time being horticultural products accessible to consumers, explaining the cultivation almost throughout the entire year in different culture systems: protected spaces, early, summer, and autumn crops, with red cabbage being mainly produced in summer-autumn crops. Cabbage heads are an important source of carbohydrates (4-6.5%), proteins (1.5-2%), vitamins (C 45-75 mg), carotene (0.2-2 mg), B1, B2 , B6, P, K, H and mineral salts: potassium (200-216 mg), phosphorus (80 mg), calcium (33-68 mg), magnesium (20-24 mg) reported per 100 mg of fresh substance, as well as volatile substances with bacteriostatic action (R. Ciofu et al, 2004).

Cabbage is also important due to its therapeutic properties, being recommended in the treatment of wounds, stomach ulcers, having a positive effect on digestion. Moreover, the sauerkraut obtained through lactic acid fermentation preserves very well, without suffering significant degradation, contributing to supplementing the necessary vitamins, minerals and lactic bacteria beneficial to the human body.

For storage and preservation, late varieties are used, harvested at a degree of maturity of the heads correlated with the destination of capitalization, the main criterion being the degree of fullness of the heads. For storage, a medium filling degree is sought (Amaruței, Alexandrina et al., 1984). After this stage, the heads are exposed to cracking, especially those too dense and with developed axial buds (Beceanu D., 2000). During the recent decades, storage-resistant cultivars and hybrids have been obtained, characterized by a longer storage period, with dense heads, tissues with smaller cells and thicker membranes.

Harvesting is done in dry weather, without precipitation, after the hoar-frost has lifted (October-November), and the temperature of the products lower or equal to the air temperature. Irrigation of the crop must be stopped 10-14 days before harvesting. Autumn cabbage is harvested in one pass. Labor consumption is significant, and the quality of the heads depends on the correct way of harvesting. The well-formed heads, normally developed, are cut smoothly with a spine of a maximum of 1 cm from the shell, with 1-2 protective leaves.

With the harvest, the first conditioning operation is carried out, namely the pre-sorting

of the heads. Whole, fresh-looking, uncracked, healthy heads, without signs of impact or other damage, without damage caused by frost, clean, with a healthy spine and neophyllous protective leaves, well attached, are chosen for preservation. Only extra and first quality specimens are accepted for storage and preservation. Conditioning continues with sorting and calibration operations. For first quality, only slight defects or small injuries that do not cause depreciation are accepted, with the weight for autumn varieties of white cabbage being 2-3 kg/piece, and for red cabbage 1.2-1.8 kg/piece.

The storage and preservation of cabbage heads can be done in refrigerated warehouses, warehouses with controlled atmosphere, ventilated macrosilos, improvised spaces with natural ventilation, surface or semi-buried silos.

Storage in cold stores is carried out at a temperature of 0-1^{0}C and a relative air humidity of 85-90%, and in Western Europe it is kept at -1-0^{0}C, with a relative air humidity of 95%. In warehouses with controlled atmosphere, storage temperature of -1- 0^{0}C, relative air humidity 95%, and air composition of: 2-3% O2, 3-5% CO2, storage between 2-6 months depending on the hybrid or variety was allowed (Moras, Ph. and Chapon, J.Fr, 1984). In our country, the preservation of the Buzău variety was possible for 120 days under controlled atmosphere conditions: temperature 0-0.5^{0}C, relative air humidity 90-92%, 3% O2, 5% CO2, with total losses of 21%, while refrigerated storage in normal atmosphere recorded 32% total losses in 90 days, and in silo 49.1% total losses in 60 days of storage. (Bogoescu, M. And col., 1995, A. Ardelean, 2013, Beceanu D, Balint G., 1999, Beceanu D., 1998, 2002, 2003. Burzo I., 1984, 1986, Ceaușescu I., 1987, Gherghi A., 1981, 1983, 1987, 1989, 1994, Marca Gh., 1987, 2004, Potec I., 1983, 1985, Milică C., 1988, Radu I.F.,1967).

MATERIAL AND METHOD

The varieties of Brunswick white autumn cabbage and Black Head red cabbage were studied. The research was carried out in the autumn-winter of 2020-2021.

The autumn crop was established by seedling, on land prepared in the autumn of the previous year by deep plowing and fertilization with organic and mineral fertilizers. Before the cabbage crop, early potatoes were grown. Before planting the seedling, a superficial mobilization of the soil was carried out and complex fertilizers were administered.

The seedlings were planted in June. The maintenance works carried out were: filling gaps, manual weeding, phased fertilization with ammonium nitrate and potassium salt, repeated waterings, combating diseases and pests (*Peronospora brassicae*, cabbage hernia *Plasmodiophora brassicae*, cruciferous fleas *Phyllotreta sp.*, bedbugs *Euriderma sp.*, fly *Delia brassicae*, gray louse *Brevicoryne brassicae*, cabbage weevil *Mamestra brassicae*, white butterfly *Pieris brassicae*). The treatments were carried out with fungicides and insecticides, to which aracet is added for the adhesion of the substances to the leaves.

The harvesting of white and red cabbage heads was performed by hand at the end of October, after the fall of the first hoar-frosts, accelerating the ripening of the heads.

Simultaneously with the harvesting, pre-sorting was carried out, thus separating the heads intended for preservation. These were packed separately in P-type crates.

Before the harvesting campaign, the packaging (type P crates) and the storage spaces (shed) were prepared by repairing the spaces and crates, disinfecting them with whitewash 2% and spraying with copper sulfate solution 2%.

Before storage, the heads were sorted and calibrated.

The storage was carried out for two months, in the warehouse, where the regulation of the environmental factors (temperature, relative air humidity and the circulation of air currents) was carried out by ventilation, by opening the windows and the door. Storage of crates was done in parallel rows, leaving enough space to check each crate and spaces between the rows of crates and the warehouse walls.

In the first part of the storage (October-November), the temperature and relative humidity of the air was regulated by repeated ventilations, and when the temperature dropped below 0^{0}C the ventilations were reduced, while at temperatures of -1^0 and up to-2^{0}C, the crates were covered with mats.

Throughout the storage, the health status of the heads was evaluated every three days, as well as the qualitative and quantitative depreciations occuring.

RESULTS AND DISCUSSIONS

After the conditioning operation, head samples were taken from the two varieties and chemical and organoleptic determinations were performed. In this sense, the content in soluble dry matter and vitamin C were quantitatively determined. From an organoleptic point of view, the following characteristics were analyzed: the shape specific to the variety, the color and condition of the leaves, the degree of filling of the roots, the specific mass.

The content in soluble dry matter and vitamin C are shown in Table 1.

Table 1

Soluble dry matter and vitamin C content of white and red cabbage.

Variety	Soluble dry matter (%)	Vitamin C (%)
White Cabbage	5.2	45
Red Cabbage	5.8	55

The content in soluble dry matter is a very good one, recommending them for storage during the winter months. Additionally, the carbohydrate substrate is sufficient for carrying out lactic acid fermentation and obtaining pickled products. This type of fermentation is very beneficial for the state of health, because the qualitative deteriorations, especially in vitamin C, are minimal. At the same time, the intake of beneficial bacteria to the digestive system is considerable.

The vitamin C content is significant and can be a source of vitamins in the winter period, both by eating fresh and pickled.

Additionally, the specific mass and freezing temperatures of white and red cabbage varieties included in the study are presented in Table 2.

Table 2

Specific mass and freezing temperature of white and red cabbage.

Variety	Specific mass (g/cm^3)	Freezing temperature (^0C)
White Cabbage	0.92	-0.5
Red Cabbage	0.94	-1

From an organoleptic point of view, the shape of the heads was analyzed, being round flattened for white cabbage and spherical for red cabbage. At the time of harvesting, the condition of the leaves was good, they showed a good state of health, the heads being well formed and dense. Through pre-sorting and sorting, only the healthy specimens were retained, with the appropriate degree of ripening and fullness (extra and first quality). The specific mass of the heads for both varieties is sub-unitary, but close to 1, being a valuable technological indicator for practice, establishing a direct relationship between the specific mass of horticultural products and the resistance to handling, transport, storage capacity and its duration.

Storage in improvised premises could be possible for two months, until the end of December, due to the fact that the losses recorded were appreciable. Table 3 shows the type of depreciation and the total losses recorded in cabbage varieties.

The total percentage losses in the two varieties after a period of two months of storage are high and similar, determining the cessation of storage.

These losses show that the metabolic processes of the heads, namely breathing and sweating, were intense, due to the fact that the atmospheric factors (temperature, relative air humidity and the circulation of air currents) were not at optimal values. As it was a long, dry autumn with temperatures higher than the average for the period (October and November), the regulation of atmospheric factors was achieved through repeated ventilation, which led to a decrease in humidity in the storage space. Moreover, another factor is the nature of the products and their physical constitution. The products lose water through the stomata and possible cracks in the cuticle. The higher the surface area per unit volume, the faster the water loss, causing further weight loss (15.9% for white cabbage, and 14.8% for red cabbage respectively). The structure and texture of the products, as well as the degree of filling of the heads condition the speed with which they lose water and, therefore, the duration of the aging stages of the products. All these factors act in close interdependence and condition each other.

During the storage period, the health status of the heads was periodically checked and the specimens affected by various impairments were extracted, weighing and assessing each type of impairment.

Table 3

Percentage losses recorded in white and red cabbage during storage.

Type	Duration of storage (months)	Weight loss (%)	Damage losses (%)	Quantitative losses (%)	Total losses (%)
White cabbage	2	15.9	13.5	12.1	41.5
Red cabbage	2	14.8	13.2	12.9	40.9

CONCLUSIONS

The following conclusions can be drawn from the study of the behavior of white and red cabbage heads during storage in unused spaces (warehouse):

1. The soluble dry matter content at the time of harvest is good, allowing storing cabbage heads for a period of two months.

2. The content in soluble dry matter allows the use of degraded heads for obtaining pickles through lactic acid fermentation.

3. Cabbage residues (torn leaves, stem remains) were chopped and used as bird feed.

4. The content in vitamin C is significant, recommending the consumption throughout the year, especially during the winter in form of raw vegetable salads, pickles, ensuring an intake of vitamins, mineral salts and beneficial bacteria for the digestive system.

5. Cabbage heads continue their metabolic activity during storage, having an average respiratory intensity.

6. During the processes of breathing and sweating, the heads lose part of the water, an undesirable phenomenon, due to favoring dehydration.

7. These metabolic phenomena can be reduced by adjusting environmental factors (temperature, relative air humidity, air current circulation) to the required values.

8. In the unused warehouses, the control of these environmental factors was achieved through repeated ventilations at the beginning of the storage period, then, as the outside temperature dropped, the number of ventilations was reduced, and when the outside temperature dropped below the value of 0^0C, the ventilations became rarer, then at the temperature of -1 and up to-2^0C, the crates were covered with mats.

9. Qualitative and quantitative impairments are influenced by the structure and texture, as well as the degree of filling of the heads of cabbage: the number of stomata and the surface of the outer leaves being large, exposed to the aging phenomenon; the filling degree of the heads being optimal, the inner leaves were not affected by senescence.

10. Weight loss is due to dehydration, resulting in wilting of the outer leaves.

11. Spoilage losses are due to infestation with microorganisms, whose activity was influenced by atmospheric factors, namely the high temperature during the first period of storage and low relative air humidity, which required repeated ventilation.

12. All these tracked factors act in close interdependence and condition each other.

13. Following the significant losses recorded in December, it was decided to stop the storage and sale of the heads on the market.

14. Storage in unused spaces (warehouses) in the current economic conditions is a very cheap way of storage, especially at household level. For large quantities of cabbage, the amount of losses and storage costs for different storage methods must be asessed.

15. Further research is recommended on the use of cheap ways of storing both green horticultural products and other horticultural species.

REFERENCES

Ardelean, A., 2013. Technologies for keeping and processing vegetables and fruits, Editura Universității din Oradea, Oradea, Romania.

Beceanu, D., & Balint, G., P., 2000. Fresh valorisation of fruits, vegetables and flowers, Specific technologies from harvesting to storage and delivery. Ed. Ion Ionescu de la Brad, Iași, Romania.

Beceanu, D., 1994. Horticultural products technology. U.A.M.V. Iași, Romania.

Beceanu, D., 1998. Valorisation of vegetables and fruits. Ed. Ion Ionescu de la Brad, Iași, Romania.

Beceanu, D., 2002. Horticultural products technology. General Considerations. Volume I, Editura Pim, Iași, Romania.

Beceanu, D., Balint, G., & Benea, E., 1999. Professional guide for fresh fruit and vegetable valorization. Editura Bolta Rece, Iași, Romania.

Beceanu, D., et. al., 2003. Horticultural products technology, Fresh valorization and

industrialization. Ed. Economică, București, Romania.
Bogoescu, M., Bibicu, Miruna, Burzo, I., 1995, Research on the changes of some quality indicators and the nutritional value of white cabbage, under different storage conditions, Lucrări științifice ICDVPH, vol. XXI/95, București
Burzo, I., et. al., 1984. Technical guide for the management of storage factors in vegetable and fruit warehouses. Ed. Tehnică, București, Romania.
Burzo, I., et. al., 1986. Physiology and technology of storing horticultural products. Ed. Tehnică, București, Romania.
Ceaușescu, I., & Iordăchescu, C. 1987. Valorisation of fresh vegetables and fruits. Ed. CERES, București, Romania.
Dumitrescu , M. et al., 1998. Vegetable production. ArtiPrint, București, Romania.
Gherghi A., 1994. The technology of valorization of horticultural products. Keeping horticultural products fresh. U.I. Titu Maiorescu, București, Vol. 2, Romania.
Gherghi, A., et al., 1981. Technologies for storing horticultural products. Technical guidance. ICPVILF, 51/81, București, Romania.
Gherghi, A., et al., 1983. Biochemistry and physiology of vegetables and fruits, Ed. Academiei, București, 1983, Romania.
Gherghi, A., et al., 1983. Technologies for storing horticultural products. R.P.T.A.- I.C.P.V.I.L.F., București, Romania.
Gherghi, A., et al., 1989. Technological guide for storing horticultural products. Technical guidance. ICPVILF, Issue 60, București, Romania.
Marca, Gh., 1987. Technology of storage and industrialization of horticultural products. Tipografia Agronomia, Cluj- Napoca, Romania.
Marca, Gh., 2004. Keeping and processing vegetables and fruits. Ed. Risoprint, Cluj- Napoca, Romania
Milică, C. , Beceanu, D., 1988. Contributions to the study of independence between the respiration intensity of horticultural products and the temperature of the environment. I.S.I.A.I. seria Hort., volume 31, Romania.
Moras, Ph., et Chapon, J.Fr., 1984, Storage and preservation of fruits and vegetables, CTIFL, Paris.
Potec, I., et. al., 1983. Technology of storage and industrialization of horticultural products, Ed. Didactică și Pedagogică, București, Romania.
Potec, I., et. al., 1985. Technology of storage and industrialization of horticultural products. Practical Training, I.A.I., Facultatea de Horticultură Iași, Romania.
Radu, I.F., & Gherghi A., 1967. Storage and processing of horticultural products. Întreprinderea poligrafică, Cluj- Napoca, Romania.