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STUDIES REGARDING THE POSTHARVEST QUALITY MANAGEMENT OF STRAWBERRIES

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Abstract

The present study shows the main factors that influence the post-harvest quality management of strawberries. The study was carried out on 4 varieties of strawberries: Albion, Marmolada, Elsanta and Gorella, cultivated in the area of Vidra, Ilfov county, Romania. The fruits were harvested when about 90-95% of the surface of the fruit had the characteristic color of the variety. The storage period under modified atmosphere conditions was 14 days. A minimum of 7% soluble dry matter is recommended for strawberries and 10% would be excellent, as far as the consumer's expectation is concerned. The total losses, determined at the end of storage, showed values between 10.4% for the Gorella variety and 13% for the Marmolada variety. The depreciation due to rot was caused by the pathogens Botrytis cinerea and Penicillium italicum and showed values between 2.6% for the Marmolada variety and 5.1% for the Elsanta variety.

Key words**:** *post – harvest***,** *modified atmosphere, weight losses, loss due to rot*

INTRODUCTION

Temperature and rapid marketing are the two main factors that assure the quality of strawberries. While fresh strawberries are one of the most popular fruits for consumers, they are also one of the most perishable among fresh commodities [1].

The berries are very fragile and prone to mechanical injury as their thin skin suffers rapid loss of water in low humidity environments. Also, strawberries have one of the highest respiration rates of all fresh products.

Because of this, it is essential to establish a successful quality assurance program in order to have a profitable marketing program for strawberries [2, 10].

As a result, quality assurance should result in money saving. Grey mold was the major cause of loss at the wholesale and retail levels and it was associated with bruising and soft or leaky berries [4].

Quality assurance can really pay for itself and also improve product quality to the consumer.

In this context, the purpose of the paper aimed to analyze the main factors that influence the post-harvest quality management of strawberries.

MATERIALS AND METHODS

The research was carried out with four varieties of strawberries: Albion, Marmolada, Elsanta and Gorella, which are cultivated in the area of Vidra, Ilfov County, Romania.

The fruits were harvested at the stage where about 90-95% of the surface of the fruit had the color characteristic of the variety. After harvesting, the fruit were placed in plastic casseroles with a capacity of 1 kg each, and then packed in a 15 micron thick, semi-permeable LDPE film for gas and water vapor. A modified atmosphere was created inside the package, the storage temperature being 1-20 C, and the relative humidity of the air, 85-90%. The conditions were provided by the cold room in which the fruits were stored. Each strawberry variety, represented by 6 kg of fruit, was divided into 3 repetitions.

The mesurement and analysis made after harvesting and at the end of the storage period tracked the following:

-the evolution of the main physico-chemical characteristics of the fruits (soluble dry matter, total titratable acidity, ascorbic acid and sugar/acidity ratio). The content of the soluble dry matter was determinated by using the Atago electronic refractometer. The total titratable acidity was analysed by titration with NaOH 0,1N solutions. The content of ascorbic acid was determined by using the iodometric method;
- establishing the weight losses and rotten losses, by quantity and percentage;
-determining the temperature and relative air humidity into the strawberry package, using the Hanhart thermo-hygrometer.
The first part of the study presents the main aspects and factors that influence the postharvest quality management of strawberries.
Strawberries kept under modified atmosphere conditions were stored for 14 days, until they were of commercial value and could be sold.

RESULTS AND DISCUSSIONS

The main factors that influence the quality of strawberries

The most important factors for strawberry quality include:
-Ripeness level, generally assessed by percentage of pink or red colour;
-Gloss;
-Indication of freshness and absence of water loss;
-Absence of flaws such as decay, bruising and shrivelling;
-Flavour, influenced by sugars, acidity and flavour volatiles (Table 1);
-Berry size and uniformity;
-Firmness, absence of soft, overripe or leaky berries;
-Price and availability.

The quality specifications determination

When setting up a quality assurance program the first step is to determine the company's criteria for quality for the product. It is important to know your customers wants and needs and whether they are more concerned with price and availability than quality. At the same time you should know if ripeness and flavour are important for them or if the appearance is what matters the most. Different types of customers have different preferences and requirements for quality factors. As soon as the critical quality factors are determined, objective means have to be developed in order to measure those quality factors [3].
Keeping records of quality – related factors is what allows the evaluation of company performance and what can assist in management decisions regarding quality assurance [5].

Table 1. The strawberry flavour according the main quality parameters

Sugar	Acid	Flavour quality
high	high	good
high	low	bland
low	high	tart
low	low	tasteless

Source: Own determination.

The fruit ripeness at the harvest period

Quality assurance for strawberries begins in the field with variety selections.
The variables when it comes to strawberry varieties are as follows: berry firmness when ripe, sugar and acid content, disease susceptibility, and yield. The selection of the varieties to grow can have a tremendous impact on potential fruit quality. Fruits with better flavour may have lower yields or less disease resistance.
Management must decide which varieties are to be grown and the stage of ripeness at which the fruits will be harvested in order to best meet their specific goals for fruit quality [6].
As a consequence, riper fruit will have a higher sugar content and better flavour quality. Studies have shown that a percentage of customers will pay more for riper fruits with higher sugar content (soluble solids content). In order to supply consistent flavor quality to these customers, soluble solids content (SSC) should be monitored so that a minimum SSC is reached. A minimum of 7% SSC is recommended for strawberries and 10% would be excellent [8].The level of ripeness should be monitored in harvested trays to cheek picker performance.

Quality is influenced by agricultural practices

Agricultural practices and pre harvest disease control can have an immense influence on postharvest quality and storage life. Taking into consideration that postharvest fungicides are not used on strawberries, pre harvest disease control is very important. Low light intensity has been directly correlated with lower levels of ascorbic acid, red color and SSC, while high nitrogen fertilization has been associated with softer fruit, lower SSC and less flavor.

Preventing the strawberries fruit diseases and injury

It is essential to handle berries carefully during harvest and to avoid placing injured or diseased berries in the tray. Training and supervision are also critical. Harvesters should be prompted and incentivized to harvest with care. Overall harvesting quality can be improved by monitoring the harvesting trays for the presence of defects, which provides critical information to crew supervisors.

The importance of rapid cooling and adequate marketing

After harvest, the most critical factors to monitor for strawberry quality maintenance are pulp temperatures and time delays in the system. Fruit quality and shelf life are directly influenced by how fast the fruits are cooled and how close to 0^0C the pulp temperature is maintained [7].

As the time between harvest and cooling of the berries is critical for quality and shelf life, it is important for the time elapsed from harvest to cooling to be recorded along with fruit pulp temperatures. Management should decide what the acceptable time from harvest to cooling is. The delay should be no longer than one hour to avoid losses in strawberry quality and postharvest life [9]. More frequent trips to the cooler can be ensured by making an investment in additional small trucks.

The strawberries fruit cooling

Upon arrival at the cooling facility, pallets should be transported immediately to the forced – air cooler. Cooler temperature should be maintained at -1^0C to 0^0C and 90 to 95% relative humidity. The fruits should first be cooled at 0 to 1^0C and only then moved to the cold storage room. More efficient cooling can be ensured by making use of a separate cooler and cold storage rooms. In the case in which the refrigeration system cannot keep cooler air temperature near 0^0C, an additional refrigeration capability may be necessary, requiring a capital investment in quality.

Cooler air temperature and pulp temperatures of the warmest berries upon removal from the cooler should be monitored regularly. Cold storage air temperatures should also be monitored and records should be maintained for it (Table 2).

Table 2. The optimal parameters for strawberries storage

Precooling temperature	2……..3° C
Storage temperature	-1…..0° C
Transport temperature	0…….1° C
Relative humidity	90……95%

Source: International Institute of Refrigeration.

Delivery of the strawberries fruit

It is essential to pay careful attention to the transport vehicle when the product is loaded. Trucks should be cooled to near 0°C prior to product loading. Each load should be checked for the condition of the insulation, doors, cooling system and air delivery. Strawberries should be well secured and loaded in the center so as to prevent warming or freezing of product during transit. Provided that the truck conditions fail to meet the criteria established to maintain fruit quality during shipment, the buyer should be notified that the seller cannot guarantee the arrival condition of the fruit due to truck conditions.

The assurance of quality during the commercialization process

Pulp temperature should be checked and inspected for incoming products right without delay. If berries are warmer than 4°C, fruit quality could benefit from forced – air cooling. For the strawberries that have become warm during transport a small, portable forced – air cooler can be used in the cold room to cool the fruits. Alternatively, rapid cooling can also be facilitated by spreading pallets or trays in the room. Cooler temperature should be maintained at 0°C with 90 to 95% relative humidity. The condition of the transport vehicle should be checked as well as the incoming air temperature. If MA pallet bags are present, their arrival condition

should be checked and then removed to allow for product cooling. After the product has been transferred to the cooler, an inspection of berry condition should be conducted, including color, firmness, gloss, shrivel and decay. If decay is discovered, trays should be repacked as possible avoiding excessive warming of the fruit during this period.

Handling of the inferior quality product

One of most important quality assurance that management must make is to determine the minimum level of quality at which the product will continue to be marketed. A firm commitment to quality requires that difficult decisions be made – namely to discard inferior quality product, especially when additional product is unavailable and demand is high. It is advisable to record the causes of product loss, as this information can be useful for management decisions to improve product quality. At the retail level, strawberries should be kept in refrigerated cases in the cold storage room at night. If relative humidity in the above mentioned is lower than 85% what may help reduce water loss is placing clean, plastic film over the strawberry trays, as it creates a humid environment around them.

The behavior of the strawberries under modified atmosphere

During the evolution towards fruit ripening, the main physico-chemical characteristics underwent changes, so that, at harvest, they presented the values mentioned in Table 3. Thus, the soluble dry matter content ranged between 6.72% for the Albion variety and 8.16% for the Elsanta variety. The total titratable acidity was very similar for all varieties. The lowest value, of 1.62%, was measured for the Albion variety, and the highest, for the Marmolada variety, respectively 1.88%. The ascorbic acid content had the lowest value in the Marmolada variety (68.14 mg/100 g), while the highest value was determined in the Gorella variety (82.34 mg/ 100 g).

The measurements performed at the end of the 14 days of storage in the modified atmosphere, showed lower values for all the analyzed parameters, compared to the results obtained immediately after harvest. We mention only the sugar/acidity ratio, which had values between 4.19 for the Albion variety and 4.77 for the Elsanta variety.

Table 3. The main physic-chemical parameters of strawberries

Variety	Analysis time	Soluble dry matter -%-	Total titratable acidity -%-citric acid	Ascorbic acid -mg/100 g-	Sugar/acidity ratio
ALBION	At harvest	6.72	1.62	72.24	4.15
	End of storage	6.54	1.56	68.72	4.19
MARMOLADA	At harvest	7.86	1.88	68.14	4.18
	End of storage	6.94	1.62	63,62	4.28
ELSANTA	At harvest	8.16	1.72	80.18	4.75
	End of storage	7.44	1.56	74.26	4.77
GORELLA	At harvest	7.46	1.68	82.34	4.44
	End of storage	6.82	1.60	77.26	4.26

Source: Own determination.

The behavior of the strawberry varieties during storage was different, regarding weight losses, rotten losses and physiological disorders, as it results from the data presented in Table 4.

Thus, the weight losses ranged between 6.2% for Elsanta variety being significantly negative and 10.4% for the Marmolada variety, the differences from the average being distinctly significantly positive.

The rotten losses measured at the end of storage under modified conditions had values between 2.6% for the Marmolada variety and 5.1% for the Elsanta variety. The main pathogens involved in fruit depreciation were *Botrytis cinerea* and *Penicillium italicum.*

The total losses, represented by the sum of the losses due to rot, had values between 10.4% for the Gorella variety (significantly negative differences) and 13% for the Marmolada variety (distinctly significant differences).

The physiological disorders manifested mainly by changes in taste and flavor, or color changes, recorded relatively small values, ranging between 2.1% for the Albion variety and 3.7% for the Marmolada variety.

Table 4. Total and qualitative losses of strawberries at the end of storage

Variety	Weight losses		Rotten losses -%-	Total losses		Physiological disorders %
	%	Signification grade		%	Signification grade	
ALBION	6.9	°	4.6	11.5	-	2.1
MARMOLADA	10.4	**	2.6	13.0	**	3.7
ELSANTA	6.2	°	5.1	11.3	-	2.4
GORELLA	6.3	°	4.1	10.4	°	2.8
AVERAGE VALUE	7.4	-	4.1	11.5	-	2.7

Source: Own determination

Legend: ** = distinctively significantly positive;
* = significantly positive;
°° = distinctly significantly negative;
° = significantly negative;
- = insignificant

CONCLUSIONS

The main characteristics that define the quality of strawberries at harvest are: the colour, taste and aroma of the fruit.

Strawberry fruits do not continue to ripen after harvest and will not increase in sugar content; therefore, riper fruit will have higher sugar content and better flavour quality.

As far as the consumer's expectations are concerned, a minimum of 7% soluble dry matter is recommended for strawberries and 10% would be even more desirable.

Agricultural practices and controlling pre-harvest diseases have an important influence on postharvest quality and storage life, due to the fact that postharvest chemical treatments are not allowed on strawberries.

As strawberries are very perishable, it is recommended to harvest the fruit directly in the transport and storage packaging, in order to reduce the number of handling sessions and depreciation of the fruit. After harvesting, the faster the fruits are cooled and the closer the pulp temperature is maintained to 0 to 1^{o}C, the higher the fruit quality and the longer the shelf life.

A critical element for the quality and shelf life of strawberries is the time period between harvesting and the cooling storage of the fruits.

The optimal duration of storage in conditions of modified atmosphere of the fruits of the 4 studied strawberry varieties, was 14 days.

At the end of storage, the soluble dry matter content was between 6.54% for the Albion variety and 7.44% for the Elsanta variety, and the total titratable acidity varied between 1.56% for the Albion and Elsanta varieties, respectively 1, 62% for the Marmolada variety.

Weight loss during storage ranged from 6.2% for Elsanta to 10.4% for Marmolada, and depreciation due to rot ranged from 2.6% for Marmolada to 5.1% for Elsanta.

The losses due to rot were mainly caused by the pathogens *Botrytis cinerea* and *Penicilium italicum.*

REFERENCES

[1]Almeida, M.L.B., Moura, C.F.H., Inneco, R., Dos Santos, A., Miranda, F.R., 2015, Postharvest shelf life and fruit quality of strawberry grown in different cropping systems, African Journal of Agricultural Research, Vol.10(43), 4053 – 4061.

[2]Baicu, A.A., Popa, M.E., 2018, Trends in prolonging the post-harvest life of strawberries – A review, The Annals of the University Dunărea de Jos of Galați, Fascicle VI – Food Technology, 42(1), 9 – 16.

[3]Caner, C., Aday, M.S., Demir, M., 2008, Extending the quality of fresh strawberries by equilibrium modified atmosphere packaging. European Food Research and Technology, 227, 1575 – 1583.

[4]Chira, L., Chira A., Ion, L., 2021, Research regarding the economic efficiency and qualitative aspects of some new apple varieties during storage under modified atmosphere, Scientific Papers, Series "Management, Economic Engineering in Agriculture and Rural Development" , Vol. 21(1), 125-133.
[5]Giampieri, F., Tulipani, S., Alvarez-Suarez, J.M., Quiles, J.L., Mezzetti, B., Battino, M., 2012, The strawberry: Composition, nutritional quality, and impact on human health. Nutrition, 28, 9 – 19.
[6]Gol, N.B., Patel, P.R., Rao, T.V.R., 2013, Improvement of quality and storage decay of strawberry. Postharvest Biology and Technology, 75, 24 – 27.
[7]Mali, S., Maria, V., Grossmann, E., 2003, Effects of yam starch films on storability and quality of fresh strawberries, Journal of Agricultural and Food Chemistry, 51, 7005 – 7011.
[8]Park, J.E., Kim, H.M., Hwang, S.J., 2012, Effect of harvest time, precooling, and storage temperature for keeping the freshness of strawberry for export. Journal of Bioenvironment Control, 21(4), 404 – 410.
[9]Reddy, M.V.B., Belkacemi, K., Corcuff, R., Castaigne, F., Arul, J., 2000, Effect of pre-harvest chitosan sprays on post-harvest infection by Botrytis cinerea and quality of strawberry fruit. Postharvest Biology and Technology, 20, 39 – 51.
[10]Soare, E., Chiurciu, I.-A., 2021, Study regarding the production and marketing of strawberries in Romania, Scientific Papers, Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 21(1), 699-704.