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THE INFLUENCE OF STORAGE TEMPERATURE ON THE WEIGHT OF GOLDEN DELICIOUS APPLES

Author(s):
S. Kassebi [1], P. Korzenszky [2]

Affiliation:
[1] Doctoral School of Mechanical Engineering – Hungarian University of Agriculture and Life Sciences, 2100 Gödöllő, Páter Károly u. 1., Hungary;
[2] Institute of Technology – Hungarian University of Agriculture and Life Sciences, 2100 Gödöllő, Páter Károly u. 1., Hungary;

Email address:
kassebi.salma@phd.uni-mate.hu; korzenszky.peter.emod@uni-mate.hu

Abstract: The great majority of customers choose nutritious, fresh fruit with a distinct color for human ingestion. The Golden Delicious apple is a popular yellow-colored, delicate, sweetish, somewhat acidic, crisp-fleshed, juicy, fragrant, and aromatic apple. Apples, like other fruits, are stressed throughout their development and growth in the field, as well as during harvest and the postharvest environment (processing, storage, transportation). The refrigerated system enables bulk processing of food goods from harvest to market, guaranteeing that freshness and integrity are preserved for a prolonged time through precise temperature and humidity regulation. This study looked at the effects of three months of storage on the weight loss of Golden Delicious apples, both under refrigerated settings at 5±0.5°C and 82% relative humidity and in controlled ambient conditions at 25±0.5°C relative humidity and 60% relative humidity. The results showed that the weight loss in the two groups of apples was different. Apples held in cold storage lost 3.31g to 4.59g of weight; meanwhile, apples stored at room temperature lost 23.29g to 31.76g of weight.

Keywords: Golden Delicious apples, storage, weight loss, shelf life, temperature

1. Introduction

Unlike other perishable foods such as meat, fruits and vegetables are living tissues that continue to breathe and transpire even after being separated from the plant [1]. Sugars, salts, organic acids, minerals, water-soluble dyes, vitamins, and nondigestible carbohydrates are essential to fruit components of a balanced human diet [2]–[4].

Water makes around 75–90% of the total bulk of fruits. The ultimate water content of fruits and vegetables is generally determined by structural variations [5]. Substrate and water losses in the parent plant are compensated by a continuous flow of photosynthates, minerals, and water before harvest; however, these losses are not restored in the postharvest channel [6]. As a result, these foods begin to degrade and finally spoil, diminishing their shelf life and quality.

Various factors determined the percentage of deterioration, most of which are internal, such as internal tissue conditions, which can be affected by different mechanical interactions during harvest or transportation [7]. The external factors are also important, such as temperature and relative humidity during storage (RH%) [8].

The apple is among the world's most fleeting and significant fruits, primarily cultivated in temperate climates. There are around 7500 apple varieties, although only a few are famous worldwide. Golden Delicious is a popular variety that is grown throughout the world. It is a significant crop with an annual production of 83 million tonnes [9]. Apples are one of the most consumed fruits in Europe. In 2021, the apple production in Europe was 11.735,000 T. Golden Delicious production was 2.120.000 T. Apple is one of the main fruits available in Hungary for fresh consumption and postharvest storage. In 2021 the total production of apples was 520.000 T, for Golden Delicious was 50.000 T [10]. Only a small percentage of apples are

consumed right after harvesting, and consumers must conserve a significant part of them for a long time to ensure their preservation for future consumption [11].

Apple seems like one of those fruits for which the quality degrades fast over time while storing, resulting in a wide range of customer satisfaction. Consumers dislike fruits that are low in weight, colourless, and withered [12]. Apples are collected and processed in late summer and fall; however, they are readily accessible pretty much all season.

The most significant environmental element impacting the degradation of harvested and stored fruit is temperature [13]. The temperature has a considerable impact on how other internal and external variables influence the fruit and its shelf life [14]. As a result, it is essential to maintain constant control over this component [15]. While lower storage temperatures might cause cold damage, higher temperatures can significantly decrease the product's shelf life. Many studies have been carried out to investigate the effect of storage temperature on fruit quality and shelf life [16]–[20]. The results show that temperature has a substantial impact on postharvest fruit quality.

Cold storage is the foundation for preserving fruit quality over long periods [21]. Using cold storage helps to reduce the respiration rate of fruits and vegetables and extends the shelf life. Previously, people generally consumed fruits completely at their production site; but, technological improvements in postharvest and commercialization technology have permitted shipping fruits to be sent to distant locations and consumed within a few to several days of collection. This approach emphasizes the need to retain natural characteristics and freshness from farm to remote customer.

The objective of this study was to determine the effects of storage temperature on the postharvest weight change of apple (Golden Delicious) fruit, which is an essential aspect of quality conditions.

2. Materials and Methods

Apple fruit "Golden Delicious" were collected directly from the same farm, "Kecskemét," located in Hungary. The fruit sample average weight was 160 ±60 g.

Apples have been subjected to a screening and selection operation to remove any damaged fruit. Samples were divided into two groups; each one was composed of 12 apples with identification: the first group, named AO: Apple Outside cold storage, was stored in the laboratory at an ambient environment (To=25±0.5°C, with the relative humidity of φ=60RH%). The second group was placed in a cold storage refrigerator. The storage temperature was set at Ti=5±0.5°C with relative humidity of 82 %, and the identification was AI: Apples Inside cold storage.

The following materials were used to experiment: Cold storage room' FRIGOR-BOX' with nominal 3.7m^3 capacity and a precision scale type KERN PCB (3500±0.01g). (Figure 1)

Figure 1. KERN PCB-type laboratory balance for measuring weight loss

All apples were weighed before, during, and after the storage period in 3 replicates. The same samples were evaluated for weight loss once a week for 3 months.

Weight loss (Δm) was determined as follows: $\Delta m = m_0 - m_i$ [g], where m_0 indicates the initial fruit weight [g] at harvest and mi shows the fruit weight [g] during storage. Weight loss was calculated by the difference in the weight before and after storage, results given in gram. The measurements were performed in the Food Technology Laboratory at the Hungarian University of Agriculture and Life Sciences. Weight measurement was performed 3 times on each apple. We calculated the mathematical average of the results. For the average

data of each week, we used a linear regression function to look for trends. The difference between the equations shows the clear distinction between the two processes.

3. Results and Discussion

The Golden Delicious apples used in the experiment were kept at room temperature, and we tracked weight loss week by week. The highest measured weight of the apples at the start was between 138 and 220g using a calibrated scale.

The 12 apples of various weights were weighed and averaged in triplicate once a week. The results are presented in the figure. The effect of storage at room temperature on apple weight loss during 3 months is shown in Figure 2.

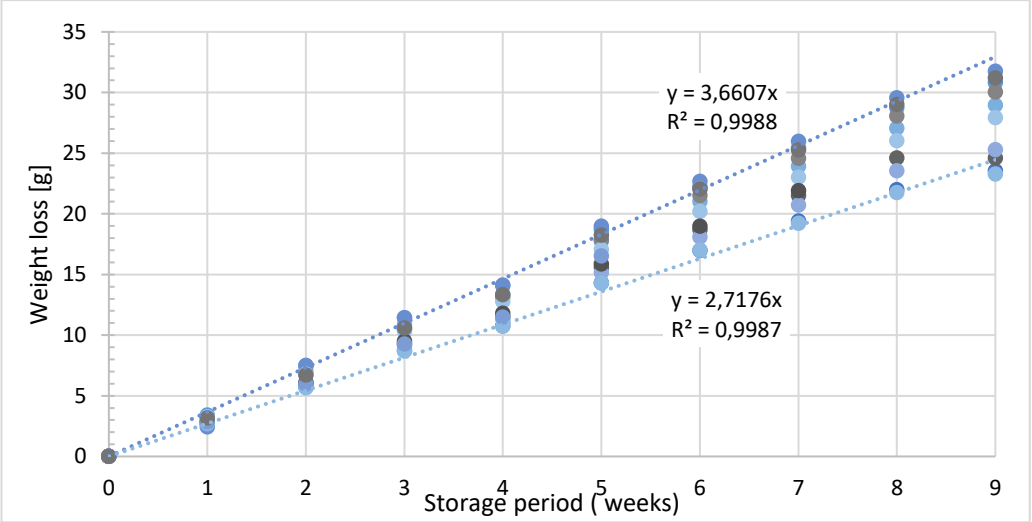

Figure 2. Weight loss of apples stored at ambient temperature during 3 months

As a result of this study, a trend line was fitted to the average price of the measurements over 9 weeks. The linear trend line with a coefficient of determination R^2= 0.99 faithfully, explained the variation in weight loss of the apples during storage.

The weight loss of apples varied between 23.29 g and 31.76g (Table 1). The mass of the fruit declined continuously. The first apple that began to shrink and perish was in week 6.

The other group of apples included in the experiment was stored in a refrigerated chamber for 3 months. (Ti=5±0.5°C; φ=82RH%). The measured weight of the apples at the start was between 135±1 and 187±1 g using a calibrated scale.

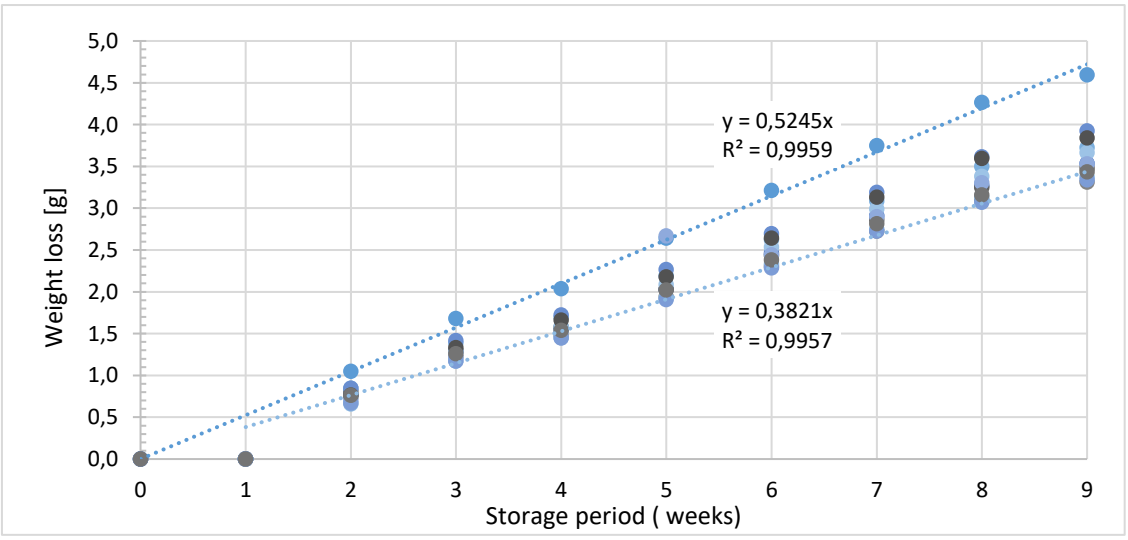

Figure 3. Weight loss of apples stored at 5±0.5°C during 3 months

The results shown in Figure 3 revealed that the mass of apples decreased between 3.31g and 4.59g after 9 weeks under cold storage. The variation in weight loss of the apples stored at 5±0.5 °C was faithfully explained by the linear trend line with a coefficient of determination R^2= 0.98.

The study showed that low-temperature treatment significantly inhibited the increase of weight loss, and 5±0.5 ℃ storage was best to the extent of the shelf life and inhibited weight loss of Golden Delicious apple.

The weight of the fruit reduced with time at both ambient and cold storage conditions. When compared to room temperature storage, cold storage exhibited significantly less change. (Table (1)).

Table1. The measured Weight loss of apples stored at 5±0.5°C and 25±0.5°C weekly

Apples stored at 25 ±0.5°C	**AO.1**	**AO.2**	**AO.3**	**AO.4**	**AO.5**	**AO.6**	**AO.7**	**AO.8**	**AO.9**	**AO.10**	**AO.11**	**AO.12**
Week 0	0	0	0	0	0	0	0	0	0	0	0	0
Week 1	3.41	2.68	2.76	3.29	2.43	3.10	3.24	2.78	2.90	2.69	2.85	3.18
Week 2	7.46	5.73	6.00	7.04	7.50	6.66	6.78	5.93	6.11	5.65	5.97	6.71
Week 3	11.43	8.75	9.28	10.84	11.44	10.51	10.31	9.16	9.50	8.69	9.27	10.59
Week 4	14.08	10.77	11.53	13.36	14.13	13.13	12.78	11.32	11.79	10.72	11.48	13.34
Week 5	18.71	14.30	15.57	17.73	18.97	17.88	17.06	15.16	15.85	14.29	16.51	18.25
Week 6	22.22	16.96	18.68	21.00	22.67	21.50	20.20	18.09	18.99	17.00	22.12	22.05
Week 7	25.42	19.40	21.50	23.92	25.96	24.57	23.02	20.72	21.90	19.22	rotten	25.27
Week 8	28.73	21.99	24.59	27.05	29.57	28.06	26.02	23.53	rotten	21.75	rotten	29.01
Week 9	30.83	23.55	24.59	28.94	**31.76**	30.04	27.94	25.29	rotten	**23.29**	rotten	31.19
Apples stored at 5±0.5°C	**AI.1**	**AI.2**	**AI.3**	**AI.4**	**AI.5**	**AI.6**	**AI.7**	**AI.8**	**AI.9**	**AI.10**	**AI.11**	**AI.12**
Week 1	0	0	0	0	0	0	0	0	0	0	0	0
Week 2	1.05	0.77	0.81	0.85	0.85	0.74	0.76	0.70	0.77	0.66	0.67	0.76
Week 3	1.68	1.28	1.30	1.39	1.42	1.22	1.29	1.22	1.33	1.17	1.17	1.26
Week 4	2.04	1.56	1.58	1.70	1.72	1.49	1.59	1.52	1.66	1.45	1.45	1.54
Week 5	2.64	2.03	2.03	2.19	2.27	1.94	2.09	2.67	2.18	1.93	1.91	2.02
Week 6	3.21	2.46	2.43	2.62	2.70	2.30	2.53	2.44	2.64	2.33	2.29	2.38
Week 7	3.75	2.91	2.86	3.09	3.19	2.73	2.99	2.90	3.13	2.75	2.73	2.81
Week 8	4.27	3.27	3.25	3.50	3.61	3.11	3.38	3.30	3.60	3.13	3.07	3.16
Week 9	**4.59**	3.53	3.48	3.72	3.92	**3.31**	3.66	3.53	3.84	3.37	3.34	3.43

Apples held in cold storage lost between 3.31g and 4.59g of weight; meanwhile, apples stored at room temperature lost between 23.29 g and 31.76g of weight.

Storage at the two different temperatures significantly impacted the weight of the fruit. Fruit that has lost weight generally appears shrivelled and unappealing. There were significant alterations in the weight loss of apples placed at ambient temperature.

4. Conclusions

When picked at its height of ripeness, the fruit is a tasty, healthy, and colourful part of the daily diet, as it is generally attractive and very healthy, however, an apple continues to live and breathe even after being picked, which led to quality changes. Although it is impossible to stop respiration completely, postharvest cooling aims to slow down the process and thus increase shelf life.

This paper studied the changes in weight loss of Golden Delicious apple fruits during storage at room temperature and cold storage. The weight loss of cold-stored samples was inhibited, indicating that the internal transpiration of the apples mainly influenced the weight loss.

Fruits respond to postharvest conditions with desirable changes if proper protocols are applied, but otherwise, they may develop negative and unacceptable characteristics due to physiological disorders. In further studies, we will investigate the effect of different storage conditions on the variation of measurable parameters of fruit.

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