Science, Technology and Innovation
ISSN 2544-9125 ▪ 2021; 12 (1): 7-11
doi: 10.5604/01.3001.0015.5265

STI • 2021;12 (1): 7-11

The effect of post-harvest storage on the weight of *Golden Delicious* apples

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Original article

Abstract

Apples, like other fruits, are exposed to stress during their growth and development in the field, also during harvest and the postharvest environment (processing, storage, and transportation). The refrigeration system allows for bulk handling of food products from harvest to market, ensuring that food products are maintained in their freshness and integrity for an extended period through careful management of storage temperature and humidity. This study investigated the effects of storage on the weight loss of apples (*Golden Delicious* fruits harvested at maturity), under refrigerated conditions at a temperature of 5 ± 0.5°C and relative humidity of 82% and under ambient storage at a temperature of 25 ± 0.5°C and relative humidity of 60%, over 3 months.

The findings revealed that the two groups of apples experienced weight reduction at different levels. Apples placed at cold storage presented a loss of weight between 3.31 g and 4.49 g; however, apples stored at ambient temperature showed a significant loss of weight between 21.90 g and 31.76 g.

Keywords

- Golden Delicious apples
- storage
- weight loss
- shelf life

Authors contributions

A – Conceptualization
B – Methodology
C – Formal analysis
D – Software
E – Investigation
F – Data duration
G – Visualization
H – Writing – original draft preperation
I – Writing, reviewing & editing
J – Project administration
K – Funding acquisition

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Article info

Article history

- Received: 2021-09-28
- Accepted: 2021-11-20
- Published: 2021-11-20

Publisher

University of Applied Sciences in Tarnow
ul. Mickiewicza 8, 33-100 Tarnow, Poland

Financing

The study was supported by the Stipendium Hungaricum Program and the Mechanical Engineering Doctoral School, The Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary.

Conflict of interest

None declared.

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, 3]. 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 [4]. 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 [5]. 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 [6]. The external factors are also important, such as temperature and relative humidity during storage (RH) [7].

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 throughout the world. 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 [8]. 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 [9].

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 [10]. 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 [11]. The temperature has a considerable impact on how other internal and external variables influence the fruit and its shelf life. As a result, it is essential to maintain constant control over this component [12]. 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 [13–16]. 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 [17]. 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.

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 ($T_o = 25 \pm 0.5$°C, with the relative humidity of $\varphi = 60$RH%). The second group was placed in a cold storage refrigerator. The storage temperature was set at $T_i = 5 \pm 0.5$°C with a 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 3.7 m^3 capacity and a precision scale type KERN PCB (3500 ± 0.01 g).

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: $Dm = A - B$ [g], where A indicates the initial fruit weight [g] at harvest and B shows the fruit weight [g] after storage intervals. 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.

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 220 g 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 1.

As a result of this study, a trend line was fitted to the average price of the measurements over 9 weeks.

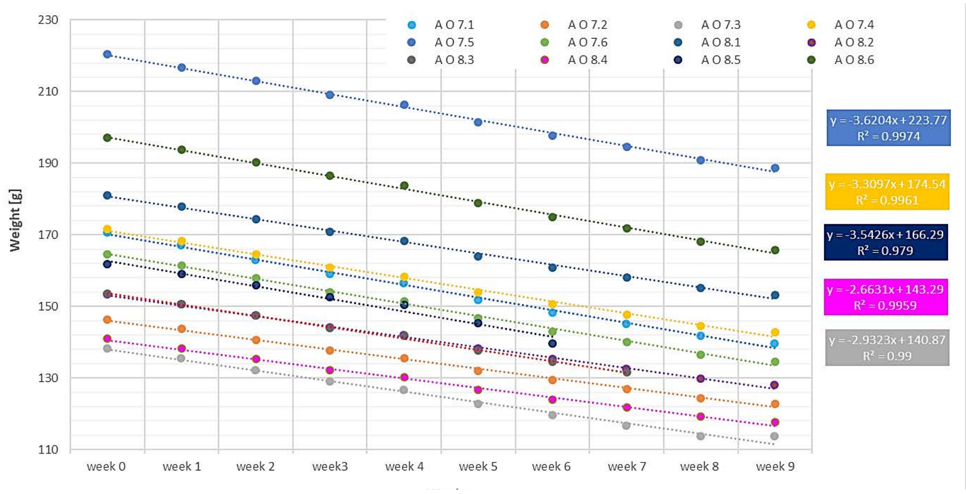

Figure 1. Weight loss of apples stored at ambient temperature during 3 months

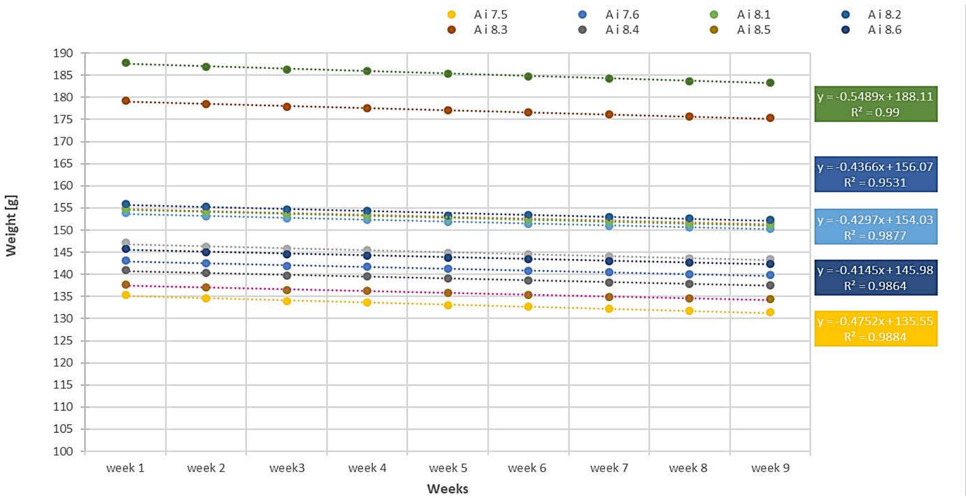

Figure 2. Weight loss of apples stored at 5 ± 0.5°C during 3 months

The trend showed a linear relationship between $R_2 = 0.97 - 0.99$. The slopes of the linear lines fell between −2.66 and −3.62.

The weight loss of apples varied between 23.55 g and 31.76 g. The mass of the fruit declined continuously. The first apple that began to shrink and perish was in week 6th (Figure 1).

The other group of apples included in the experiment was stored in a refrigerated chamber for 3 months. ($T_i = 5 \pm 0.5$°C; $\varphi = 82$RH%). The measured weight of the apples at the start was between 135 ± 1 and 187 ± 1 g using a calibrated scale (Figure 2).

The results shown in Figure 2 revealed that the mass of apples decreased between 3.31 g and 4.49 g after

9 weeks under cold storage. The trend showed a linear relationship between R_2 = 0.95 – 0.99. The slopes of the linear lines fell between −0.4 and −0.54.

The study showed that low-temperature treatment significantly inhibited the increase of weight loss, and 5 ± 0.5°C 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).

Table 1. Average of the measured weight of apples stored at 5 ± 0.5°C and 25 ± 0.5°C weekly and the final weight loss

Apples stored at 25 ± 0.5°C	AO7.1	AO7.2	AO7.3	AO7.4	AO7.5	AO7.6	AO8.1	AO8.2	AO8.3	AO8.4	AO8.5	AO8.6
week 0	170.45	146.37	138.19	171.65	220.43	164.54	181.11	153.27	153.55	140.97	161.86	197.03
week 1	167.05	143.69	135.43	168.37	216.68	161.44	177.87	150.49	150.64	138.29	159.01	193.85
week 2	162.99	140.64	132.19	164.62	212.93	157.88	174.33	147.34	147.44	135.33	155.89	190.32
week3	159.03	137.62	128.91	160.81	209.00	154.04	170.80	144.11	144.05	132.29	152.59	186.44
week 4	156.37	135.60	126.66	158.29	206.30	151.41	168.33	141.95	141.76	130.25	150.38	183.69
week 5	151.75	132.07	122.62	153.92	201.46	146.67	164.05	138.11	137.69	126.68	145.35	178.78
week 6	148.23	129.41	119.51	150.65	197.76	143.04	160.91	135.19	134.56	123.97	139.74	174.98
week 7	145.04	126.97	116.69	147.73	194.47	139.97	158.09	132.56	131.65	121.76	rotten	171.76
week 8	141.72	124.38	113.60	144.61	190.86	136.49	155.09	129.74	rotten	119.22	rotten	168.02
week 9	139.62	122.82	113.60	142.71	188.67	134.50	153.17	127.98	rotten	117.68	rotten	165.84
Loss (g)	**30.83**	**23.55**	**24.59**	**28.94**	**31.76**	**30.04**	**27.94**	**25.29**	**21.9**	**23.29**	**22.12**	**31.19**
Apples stored at 5 ± 0.5°C	**AI7.1**	**AI7.2**	**AI7.3**	**AI7.4**	**AI7.5**	**AI7.6**	**AI8.1**	**AI8.2**	**AI8.3**	**AI8.4**	**AI8.5**	**AI8.6**
week 1	187.85	153.86	155.01	147.12	135.36	143.18	154.85	155.92	179.21	140.94	137.69	145.84
week 2	186.90	153.09	154.21	146.27	134.51	142.44	154.09	155.21	178.45	140.29	137.02	145.08
week3	186.27	152.58	153.71	145.73	133.94	141.96	153.56	154.70	177.88	139.77	136.52	144.58
week 4	185.92	152.30	153.44	145.42	133.63	141.70	153.26	154.40	177.55	139.49	136.24	144.30
week 5	185.31	151.83	152.98	144.92	133.09	141.24	152.76	153.25	177.03	139.02	135.78	143.82
week 6	184.74	151.40	152.58	144.49	132.66	140.88	152.32	153.47	176.57	138.61	135.40	143.46
week 7	184.21	150.95	152.15	144.03	132.17	140.46	151.86	153.02	176.08	138.19	134.96	143.02
week 8	183.69	150.59	151.77	143.62	131.74	140.08	151.47	152.61	175.62	137.81	134.62	142.68
week 9	183.36	150.33	151.54	143.39	131.43	139.87	151.19	152.39	175.37	137.57	134.35	142.40
Loss (g)	**4.49**	**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 3.31 g and 4.49 g of weight; meanwhile, apples stored at room temperature lost between 21.9 g and 31.76 g of weight. Storage at the two different temperatures significantly impacted the weight of the fruit. Fruit that has lost weight generally appears shriveled and unappealing. There were significant alterations in the weight loss of apples placed at ambient temperature.

Conclusions

When picked at its height of ripeness, the fruit is a tasty, healthy, and colorful 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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