

Effect of storage time on respiration rate of strawberry (cv. Elsanta) sourced from some retail outlets in United Kingdom

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ABSTRACT

Strawberry (*Fragaria ananassa* Duch.) is a commercially cultivated horticultural fresh product grown in the temperate regions for its economic and nutritional value. Elsanta is one of the most popular strawberry varieties grown in the United Kingdom. Strawberries have high respiration rate which makes them more perishable with short storage life. This study investigated the effect of storage time on respiration rate of strawberry (cv. Elsanta) sourced from some retail outlets in United Kingdom (ASDA, Morrison, Marks & Spencer, Sainsbury, Tesco, and Waitrose) at constant temperature (5⁰C) for six days storage period. Three different trials were conducted and the overall mean respiration rates (ml CO₂/kg/hr) recorded showed that the fruit from Marks & Spencer recorded the lowest reading (19.68 ± 1.10) and that from Sainsbury recording the highest (26.53 ± 1.16). Statistical analysis performed using the One-way ANOVA test showed that there was a significant difference between M & S and Sainsbury [Q\ p(same) < 0.01148]. Results revealed that respiration rate of strawberry increased with storage time. The presence of ethylene absorbing strips in M & S packaging are thought to have influenced the respiration rate, weight loss and decay incidence as lower readings were recorded. Results revealed that the respiration rate had much influence on weight loss as there was a significant difference between the of respiration rate and weight loss (p < 1.868 x 10⁻⁴) for the strawberries from the various retail outlets monitored. Also, high mean percent decay of fruits on day 0 due to physical dry and wet bruises as well as some rots contributed to the high respiration rates recorded. It was concluded that even though the same variety of strawberry (cv. Elsanta) was analyzed, the rate of respiration of strawberries increased with storage time and also varied at constant temperature (5⁰C)

due to the way strawberries were handled and stored at different temperatures by the various retail outlets monitored.

Key words: Respiration rate, strawberry (cv. Elsanta), ethylene strips, decay incidence and weight loss.

Introduction

Strawberry (*Fragaria ananassa* Duch.) which is a commercially cultivated horticultural fresh produce is a natural hybrid of two American species; *F. chiloensis* and *F. virginiana* (Donoso, 2009). The strawberry fruit probably gained its name originally from the Anglo-Saxon word “strewberige” meaning “spreading berry”. It is a member of the rose family and the only fruit with seeds on the outside. The crop is a non-climacteric, woody perennial plant with compressed stems, usually referred to as crowns from which the roots, leaves, runners and inflorescences emerge (Kader, 2002). Strawberries are widely consumed all over the world due to their attractive bright red colour, sweet flavor, aroma, texture, juiciness and taste. With modern technology and developments strawberry fruit is also processed into different forms like; juice, jam, syrups, wine, and vinegar (Donoso, 2009).

Strawberry has gradually become one of the most essential fruits in the world fruit bowl for its economic and nutritional purposes. Strawberry is one of the major fresh products that are highly ranked as health-promoting antioxidants that helps to fight the destructive effects of free radical activity to cellular structures and DNA (World’s Healthiest Foods, 2013). The fruit provides vast range of nutrients and digestion-aiding enzymes with a high nutritional source of vitamin C, manganese, fiber, folate, and iodine (World’s Healthiest Foods, 2013). According to Tulipani et al., (2009), apart from the unique combination of antioxidant and anti-inflammatory nutrient characteristics possessed by strawberry, there have been several researches to support their health benefits in three (3) major areas; Cardiovascular support and prevention of heart diseases, enhanced regulation of blood sugar, with reduced risk of Type 2 diabetes, avoidance of some cancer types including breast, cervical, colon, and esophageal cancer.

As one of the most consumed fresh fruits, its optimal source of bioactive compounds, both phytochemicals and micronutrients makes it one of the flavonoid-richest foods (Tulipani et al., 2009). Cultivation of strawberry can be done either in the open field or under protected structures (high tunnel or greenhouse) system (Santos et al., 2007). One major advantage of production under protected structures over the open field system is the extension of harvest season by a few weeks and also during the winter season. Strawberry production under protected structures leads to cultivation of high quality fruits which makes growers very competitive (Cantliffe, 2012). Picking fresh strawberries at its appropriate maturity stage enhances quality and this can only be maintained or deteriorated depending on the way they are handled and stored (Cantliffe, 2012).

Fresh produce continue to live after harvest as they constantly respire and transpire throughout their postharvest life (Kays, 1991). Postharvest losses in strawberry occur at different stages i.e. during harvesting and along the supply chain (Kadar, 2002). The effect of respiration rate has been one of the major causes of deterioration in strawberries. Strawberries have a high rate of respiration which makes them more perishable with less storage life (Silva, 2010). As respiration continues at a higher rate, compounds that influence flavor, sweetness, water content, and nutritional value are lost (Bartz and Brecht, 2003).

Bartz and Brecht (2003) reported that increase in respiration rate increases the rate of water loss which results in weight loss of the fruits causing wilting and shriveling. This effect results in poor quality and low marketability of the strawberry fruits. Hence, decreasing the respiration rate is an essential consideration in prolonging the shelf-life and quality of strawberries for consumer preference and acceptance (Silva, 2010).

This research seeks to investigate the effect of storage time on respiration rate of strawberry (cv. Elsanta) sourced from some selected retail outlets in UK at constant temperature (5°C) for six days storage period. The main aim of this research is based on the hypothesis that “The rate of respiration of strawberry (cv. Elsanta) remains constant for the first six (6) days of shelf-life at constant temperature (5°C)”.

Materials and Methods

Data Collection

The Elsanta strawberry fruits were purchased at commercial maturity from retail outlets in Chelmsford, Essex and transported to Writtle College Postharvest Unit, a partner of University of Essex, Chelmsford, United Kingdom. The Elsanta strawberries were purchased from Mark & Spencer (M & S), Waitrose, Tesco, ASDA, Morrison, and Sainsbury in standard retail packaging, three packs per store per purchase, the best available and stored in cold storage at $5^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for six (6) days. The purchases were made between mid May and mid June and all fruit was UK grown. Analysis on their respiration rate was determined by measuring the percent carbon dioxide produced as well as other parameters such as weight loss and decay incidence. Strawberries from the various retail outlets were packaged in plastic punnet with a heat sealed perforated lidded plastic film. Strawberry fruits in punnet varied in sizes and weight. The day of sample arrival was recorded as day nought (Day 0). Three different trials were conducted.

Measurement of Strawberry Rate of Respiration

The respiration rate of the Elsanta strawberry was analyzed and expressed as the rate of carbon dioxide production. The close system method was used in determining the concentration of carbon dioxide per unit weight during the respiration of the strawberry fruits and expressed as volume of carbon dioxide produced per kilogram fresh weight of strawberry per hour ($\text{ml CO}_2/\text{kg/hr}$). Plastic impermeable CO_2 measuring containers of 5L (5000 ml) capacity with lid were used. A 12-mm-diameter hole was drilled on both side of the container and was sealed with a tape to prevent gas flow. These holes enabled measurement of CO_2 using the electronic gas analyzer. Strawberries were removed from cold storage (5°C) and placed in the laboratory bench for approximately two hours to warm up to ambient temperature of approximately 18°C .

Strawberries from each retail outlet were weighed using the electronic balance (JADEVER Electronic Balance, JWE-30kg, 30k x 1g) and recorded.

Each punnet of strawberry from a particular retail outlet was put in the CO₂ measuring container and tightly closed with the lid to prevent any gaseous exchange with the external environment for a timed period of approximately two hours. The oxygen in the container is utilized by the strawberries through respiration process to produce carbon dioxide which builds up within the closed system. The 280 COMBO Gas Analyzer (David Bishop Instruments Ltd, Heathfield, E. Sussex, England) was used to measure the percent CO₂ produce by the strawberries within the closed system after the two hours period. This gas analyzer measures levels of CO₂ up to 4.95%. Before any measurement was taken, the equipment was calibrated. Calculation of the respiration rate was done using the formula below as stated by Saltveit (2004);

$$\text{Respiration rate (ml/kg/hr)} = \frac{[V_c - W_{p1} \text{ (g)}] \times \%CO_2}{W_{p2} \text{ (kg)} \times T \text{ (hr)} \times 100}$$

Where: V_c – Volume of container

W_{p1} (g) – Weight of packaging in grams

W_{p2} (kg) – Weight of packaging in kilograms

T (hr) – Time in hours

Measurement of Strawberry Weight Loss

The weight loss in strawberry fruits was measured on day three (3) and day six (6). Strawberry fruits from each retail outlet were weighed using the electronic balance (JADEVER Electronic Balance, JWE-30kg, 30k x 1g). The data was expressed as percentage of weight loss relative to the initial value (initial weight of packaging). The total weight loss of fruit was determined as the percent weight loss and was calculated using the formula below;

$$\% \text{ Weight Loss (WL)} = \frac{IW - FW}{IW} \times 100\%$$

Where: % WL – Weight Loss of fruits in percent

IW – Initial Weight of fruit

FW – Final Weight of fruit

Measurement of Strawberry Decay Incidence

Measurement of decay incidence was determined on the day of sample arrival by a visual inspection through the punnet film. Rot, dry bruise and wet bruise occurrences in strawberry packaging were assessed and evaluated visually on the day of arrival. Strawberry fruits with rot, dry bruise or wet bruise on the surface were recorded as infected fruit. Fruits with no signs of decay or bruises were recorded as healthy fruits (OK). Decay measurements were estimated as the percentage of infected fruit and expressed as percent decay incidence.

$$\% \text{ Decay} = \frac{\text{Infected strawberry fruit in package}}{\text{Total strawberry fruits in package}} \times 100$$

Data Analysis

Statistical analysis on data obtained for the various parameters measured were performed using the One-way ANOVA of the PAST computer software. Significant differences between means were estimated by Tukey's pairwise comparisons test [Q\p(same)]. All tables and graphs were prepared using Microsoft Office Excel 2010 data analysis. Results obtained were expressed as Mean \pm Standard Error (SE).

Results and Discussion

The whole experiment for this research was conducted in three different trials and the results expressed as mean \pm standard error (S.E). Table 1 shows the mean respiration rate (ml CO₂/kg/hr) of strawberry Elsanta for all the retail outlets monitored in all the three trials conducted for the six days stipulated storage period. Generally, the overall mean respiration rate recorded for all the retail outlets in the entire research showed that after a steady decrease in respiration rate from day 0 to day 1, respiration rates for all the retail outlets increased consistently from day 2 to day 6 (fig. 1).

Table 1: Mean Respiration Rates (ml CO₂/kg/hr) of Strawberry for all Retail Outlets Monitored

Day	Retail Outlet					
	ASDA	Morrison	M & S	Sainsbury	Tesco	Waitrose
0	26.85 \pm 0.52	21.66 \pm 0.81	22.69 \pm 1.37	29.48 \pm 1.11	27.52 \pm 0.58	28.53 \pm 1.94
1	17.90 \pm 0.78	16.70 \pm 0.72	15.30 \pm 2.10	21.83 \pm 0.66	20.47 \pm 3.20	17.97 \pm 1.85
2	20.26 \pm 0.96	19.17 \pm 1.63	17.02 \pm 0.63	23.07 \pm 0.77	22.66 \pm 2.80	20.08 \pm 1.91
3	22.85 \pm 1.15	21.16 \pm 2.21	18.55 \pm 0.92	25.73 \pm 0.78	24.54 \pm 2.72	21.56 \pm 1.93
4	24.98 \pm 0.65	24.19 \pm 1.06	19.81 \pm 1.35	27.71 \pm 1.27	26.11 \pm 2.96	25.14 \pm 3.15
5	27.10 \pm 0.66	25.40 \pm 0.78	21.40 \pm 1.65	28.60 \pm 1.42	27.26 \pm 3.13	26.48 \pm 2.87
6	29.21 \pm 0.72	27.79 \pm 1.28	23.01 \pm 1.29	29.32 \pm 1.74	28.64 \pm 3.2	29.29 \pm 4.69
Overall	24.16 \pm 1.53	22.30 \pm 1.43	19.68 \pm 1.10	26.53 \pm 1.16	25.31 \pm 1.11	24.45 \pm 1.64

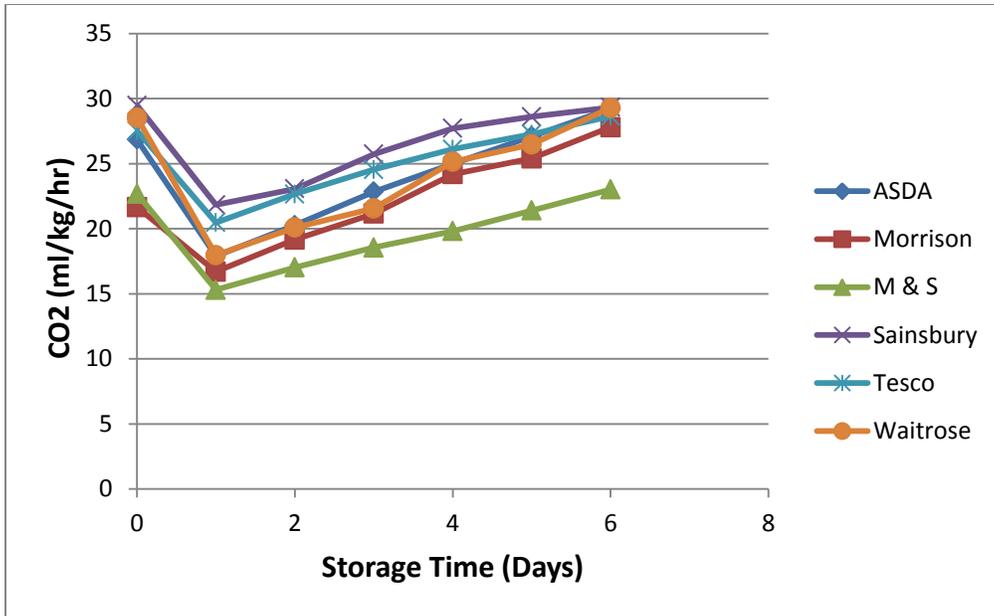


Fig. 1: Respiration rate of strawberry against storage time for all retail outlets



Fig. 2: Overall mean respiration rate (\pm S.E.) of Strawberry for all retail outlets

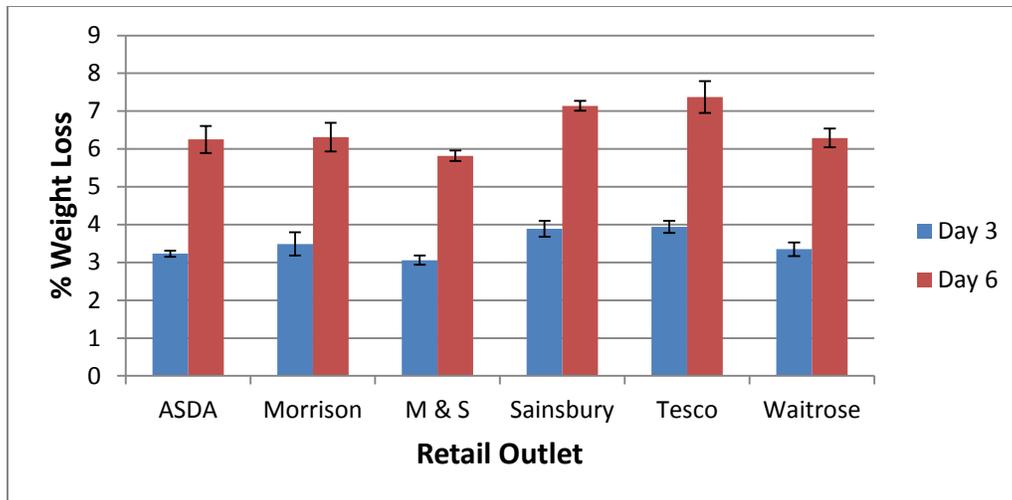


Fig. 3: Mean % weight loss (\pm S.E) of strawberry for all the retail outlets

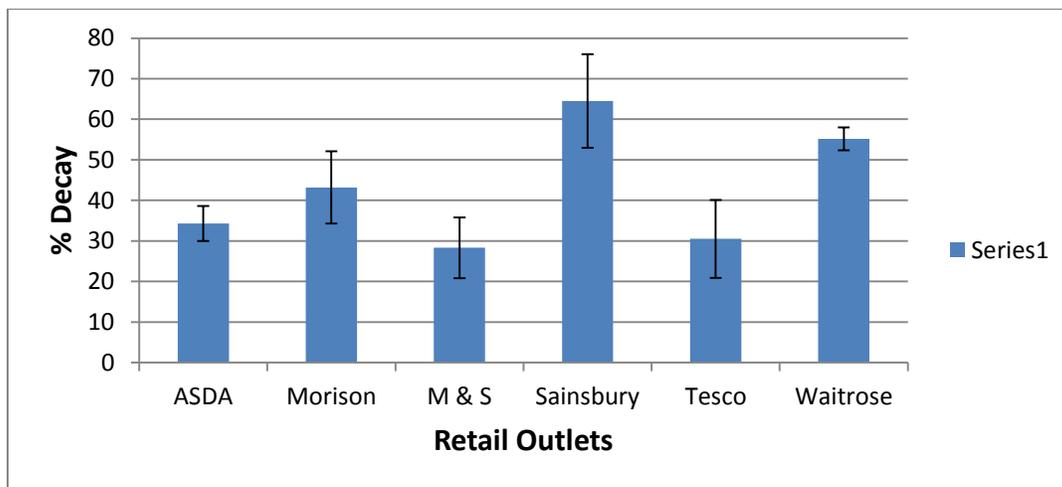


Fig. 4: Mean % Decay (\pm S.E) of strawberry for all the retail outlets on Day 0

Table 2: Mean % Decay Incidence and Weight Loss for Retail Outlets Monitored

Retail Outlet	Decay Incidence	Percent (%) Weight Loss	
		Day 0 to Day 3	Day 0 to Day 6
ASDA	34.30 \pm 4.30	3.23 \pm 0.08	6.25 \pm 0.36
Morrison	43.20 \pm 8.94	3.49 \pm 0.31	6.31 \pm 0.38
M & S	28.30 \pm 7.49	3.06 \pm 0.12	5.82 \pm 0.14
Sainsbury	64.50 \pm 11.54	3.89 \pm 0.21	7.14 \pm 0.13
Tesco	30.52 \pm 9.61	3.94 \pm 0.16	7.37 \pm 0.42
Waitrose	55.16 \pm 2.84	3.35 \pm 0.18	6.29 \pm 0.25

Results obtained from the entire experiment for Elsanta strawberry obtained from the various retail outlets showed a similar trend. The high respiration rate values recorded on day 0 was because strawberry samples from the various retail outlets arrived at different temperatures and also, fruits were agitated due to constant handling and movement. Respiration rates for day 1 decreased because the samples were stored at the same temperature (5°C) and allowed to warm up at specific time with less handling of fruits before analysis were carried out. The gradual increase in respiration rate from day 2 to day 6 could be as a result of other factors such as physical bruises or pathological decay.

The overall mean results of respiration rate ($\text{mlCO}_2/\text{kg/hr}$) for all the retail outlets showed that Mark & Spencer recorded the lowest value (19.68 ± 1.10) as compared to the other retail outlets with Sainsbury recording the highest (26.53 ± 1.16) for the six days of storage period (fig. 2). In comparing the overall mean respiration rates for all the retail outlets, results recorded in Table 1 showed that, Mark & Spencer had the minimum respiration rate, which was followed by Morrison, ASDA, Waitrose, Tesco, and Sainsbury. Statistical analysis performed using the Tukey's pairwise comparisons of the One-way ANOVA test showed that there was a significant difference ($p < 0.05$) between Mark & Spencer and Sainsbury's [$Q \setminus p(\text{same}) < 0.01148$]. However, the probability of significance between Mark & Spencer and Tesco [$Q \setminus p(\text{same}) > 0.0564$] was just close to $p < 0.05$.

Mean percent weight loss results obtained from day 0 to day 3 showed that there were not much differences in weight loss as values ranged between 3.06 ± 0.12 for Mark & Spencer to 3.94 ± 0.16 for Tesco. However, at day 6, the mean percent weight loss showed a significant increase, 5.82 ± 0.14 and 7.37 ± 0.42 for Mark & Spencer and Tesco respectively (Table 2). Even though statistical analysis performed showed no significant difference [$Q \setminus p(\text{same}) > 0.9894$] between day 3 and day 6 for all the retail outlets monitored, the final mean percent weight loss in strawberry fruits from day 0 to day 6 was very high (fig. 3). Nunes et al., (2003) reported that the maximum permissible loss of water in strawberry before marketability is impaired is approximately 6%. The findings of the undertaken research revealed that only Marks & Spencer recorded

a value (5.82%) that was lower than the 6% quoted by Nunes et al., (2003). In comparing the overall mean respiration rate with the final mean percent weight loss in day 6, statistical analysis performed however, revealed that there was a significant difference [$p(\text{same}) < 1.868 \times 10^{-4}$] between the various retail outlets even though their mean results.

Percent decay for almost all the retail outlet monitored was high due to presence of physical dry or wet bruises and some rots in strawberry packaging. The lower percent decay incidence recorded for Mark & Spencer could be as a result of the limited physical bruises (dry or wet) recorded in packaging. The presence of the ethylene absorbing strips in packaging also had effect on gray mold occurrence. On the other hand, higher percent decay incidence recorded for Sainsbury and Waitrose was as a result of high physical dry and wet bruises and some rots in strawberry packaging. Statistical analysis performed in comparing the overall mean respiration rate to the overall mean percent decay incidence showed that there was a significant difference [$p(\text{same}) < 0.0108$] for the retail outlets monitored.

Conclusion and Recommendation

The findings of this study showed that even though the same variety of strawberry (cv. Elsanta) was analyzed, the rate of respiration of strawberry fruits varied significantly between the various retail outlets monitored. Results obtained showed that the rate of respiration of strawberry Elsanta fruits did not remain constant throughout the storage period at the same temperature as statistical analysis performed revealed that there was a significant difference ($p < 0.05$) between Marks & Spencer and Sainsbury. Respiration rate increased with storage time and this makes the main hypothesis of the research that “the rate of respiration of strawberry (cv. Elsanta) remains constant for the first six days of shelf-life at constant temperature (5⁰C)” not valid. Finally, even though strawberries produces low ethylene and also not ethylene sensitive, the effect of the ethylene absorbing strips had a clear effect on the Elsanta strawberry fruits in the packaging of Marks & Spencer.

Since the ethylene absorbing strips in the Marks & Spencer packaging had effect on the respiration rate of strawberry fruits it is recommended that other retail outlets in the United Kingdom should also adopt the use of the ethylene absorbing strips in their strawberry packaging as it has great influence in controlling decay causing pathogen (*Botrytis cinerea*) and removing any ethylene produced by the strawberry fruits in packaging or present in storage environment that could enhance its quick deterioration.

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