Zagazig J.Agric. Res., Vol. 29 No.(5) 2002 1503-1512

EFFECT OF MODIFIED ATMOSPHERE TREATMENTS ON FRUIT QUALITY AND RESPIRATION RATE OF TRISTAR STRAWBERRY FRUITS

Al-Redaiman, K. N.; A. I. Al-Humaid ; and D.A. El Rayes

King Saud Univ., Al-Qassim, College of Agric., Hort. Dept., Buraidah, Kingdom of Saudi Arabia.

Received 28 / 7 / 2002 *Accepted 22 / 9 / 2002*

ABSTRACT: Mature red-ripe strawberry *(Fragaria x ananassa* Duch.*)* fruits, cv 'Tristar' were treated with different modified atmosphere (MA) treatments (O_2 at: 0, 1.5, 3.5%; and Co_2 at: 0, 15, and 25%), and were stored at either cold storage (2°C) or at ambient room temperature (21°C). Fruits physical and chemical characteristics were assessed. Low temperature storage (2°C) reduced significantly fruit weight loss compared with that stored at 21C.The least weight loss occurred in fruits stored at 15 and 25% CO_2, and the greatest loss occurred at control treatment. During the first 7 days of the experiment, no fungal growth was observed in fruits stored at low temperature (2°C). In case of fruits stored at room temperature, fungal growth was minimal in fruits stored under high CO_2 treatments (15 or 25 % CO_2) no matter what oxygen concentration was; strawberries held in 1.5 % O_2 + 25 % CO_2, and 3.5 % O_2 + 25 % CO_2 showed the least mold growth percentage. There was no significant difference among modified atmosphere treatments regarding fruit respiration rate of the fruits stored at cold storage (2°C). However, for fruits stored at ambient room temperature (21°C), there was a proportional relationship between the storage period (up to 5^{th} or 6^{th} day of treatment), as well as O_2 concentration in the MA, and respiration rate. The lowest rate of respiration was obtained form fruits stored under the MA treatments that contained zero% O_2, but differences among MA treatments were not observed consistently.

INTRODUCTION

Many trails have been carried out to improve the storage period of fresh strawberry fruits. Fresh strawberries are perishable and have a maximum shelf life of five to seven days (Courter and Kitson, 1988). They are susceptible to rapid decay due to gray mold rot, which is caused by *Botrytis cinerea* (El – Kazzaz *et al.*, 1983; and Courter and Kitson, 1988). Moreover, the respiration rate of strawberry is high and suitable postharvest handling methods are required to minimize postharvest losses (Kubod *et al.*, 1990). Some of these trails depended on relatively low temperature, as temperature management is the most important method of maintaining the postharvest quality of fruits (Mohamed *et al.*, 1986). In addition, modified atmosphere (MA) have been used commercially with some fruits (Kader, 1985). High concentration of CO_2 and / or low concentrations of O_2 reduce fruit respiration rate and inhibit fungal growth, thus extending storage life (Kader, 1985). In some cases, increasing carbon dioxide concentrations improved strawberry fruit quality (Holcroft and Kader, 1999 a; Holcroft and Kader, 1999 b; Plotto *et al.*, 1999; Sanz *et al.*, 1999; Wasna *et al.*, 1999;Wszelaki and Mitcham,2000). Moreover, elevated concentrations of CO_2 inhibited decay and retarded softening. Furthermore, the effects of elevated CO_2 persisted after removal to air (Herner, 1987). The specific objective of this research was to determine the effect of combinations of low O_2 and / or high CO_2 concentrations on weight loss, percentage mold growth, respiration rate, and ethylene production rate of 'Tristar' strawberry fruits stored at different storage temperatures.

MATERIALS AND METHODS

Mature red-ripe strawberry (*Fragaria x ananassa* Duch.) fruits, cv 'Tristar' were used for this research. This experiment was conducted for two successive seasons 2001 and 2002 in the Hort. Dept., College of Agric., King Saud Univ., Al-Qassium, Kingdom of Saudi Arabia. Fruits were obtained from a local private commercial grower. Fruits were harvested at the red-ripe stage and transported immediately to the laboratory. Fruits were fast-cooled to 5°C immediately by using forced-air cooling for 30 to 45

min. Berries then were sorted by color and size. Fruit samples were distributed into plastic mesh baskets and stored in MA chambers. The weight of each sample was approximately 300g, and each sample was considered as a replicate. Fruits were treated with the following modified atmosphere treatments:
1) 1.5 % O_2 2) 3.5% O_2 3) 25 % CO_2 4) 1.5%O_2+ 15% CO_2 5) 1.5 % O_2 +25 % CO_2 6) 3.5%O_2+ 15 % CO_2, 7) 3.5 % O_2 + 25 % CO_2, and 8) air as a control treatment. The rest of the atmospheric volume was filled with nitrogen gas (N_2). One-half of the plastic mesh baskets were placed in a cold room at 2°C, and another half were stored at room temperature (21°C). Mixtures of the desired test atmosphere were obtained. Test atmospheres were passed through MA chambers at one air exchange per hour by using capillary tubes for flow control. Samples of the test atmospheres were collected at inlets (every 24 hs) and outlets (every 12 hs) of the MA chambers and analyzed by using a Varian model 3700 gas chromatography. The test atmospheres were humidified to 85-90 % relative humidity. After seven days in the test atmosphere, final fresh weight and percentage of *B. cinerea* incidence was measured. Production rate of both CO_2 and C_2H_4 were calculated by the following formula described by Kader, 1985:

$$\frac{(O_2\%, CO_2 \text{ or } \mu l\ C_2H_4 /L/100) \text{ X flow rate (ml/ hr)}}{\text{sample weight (Kg)}}$$

A factorial experiment with three replicates per each treatment was designed. The factors included two storage temperatures (2°C and 21°C) and eight MA treatments, respectively. Analysis of variance was performed (general linear model , PROC GLM) to test the effects of the various treatments (SAS Institute , 1985) . When F values were significant, LSD was used to compare means at the 5% level.

RESULTS AND DISCUSSION

Weight Loss

A great deal of reduction occurred in fruit weight loss due to the use of cold storage. As the low temperature storage (2°C) reduced significantly weight loss of 'Tristar ' strawberry fruits when compared with fruits stored at 21°C (Table 1). Moreover, significant differences, among the MA treatments, were recorded in weight loss of "Tristar" strawberry fruits (Table 1).The least weight loss occurred when MA with 15 and 25% CO_2 was used, and the greatest fruit weight loss occurred when MA with 1.5 % O_2, 3.5% O_2, without supplementary CO_2, or air was used (Table 1). The combined O_2 and lower CO_2 concentration (1.5 % O_2 + 15 % CO_2 and 3.5 % O_2 +15% CO_2) resulted in a similar effect as the 1.5 % O_2 and air treatments. These results are in line with those of Browne *et al*. 1984; and El Rayes and Ahmed(2001) who reported that cold storage and high CO_2 concentrations reduced fruit weight loss of stored mango fruits.

Fungal Growth

Fungal growth caused by *B. cinerea* was the only from observed. No Fungal growth was observed in strawberry fruits stored at low temperature (2°C) (data were not presented). In addition, no mold growth was observed in fruits stored zero oxygen percent. The absence of oxygen retarded the growth of the mold. Moreover, fungal growth was minimal in fruits stored under high CO_2 treatments (15 or 25 % CO_2) no matter what oxygen concentration was. Berries held in 1.5 % O_2 + 25 % CO_2, and 3.5 % O_2 + 25 % CO_2 showed the least mold growth percentage. Whereas, fruits stored at either 3.5 % O_2 + 15% CO_2 treatment or air showed the greatest percentage of mold growth (Fig .1). Mohamed et al., 1986, reported that germination of spores and young mycelia of some *Rhizopus spp.* are controlled properly when fruits are stored at approximately 5°C because they are sensitive to low temperature. Moreover, some researches indicated that Low concentrations of oxygen reduced the decay of fresh strawberries caused by *B. cinerea* (Plotto *et al*. 1999). And with those of Ahmed and El Rayes(2001) who reported that carbon dioxide could be used to control fruit decay in "Red globe" table grape.

Respiration Rate

There was no significant difference among modified atmosphere treatments regarding fruit respiration rate of the fruits stored at cold storage (2°C) during the storage period (7 days)(Table 2). However, for fruits stored at ambient room temperature (21°C), there was a proportional relationship between the storage period (up to 5^{th} or 6^{th} day of treatment) and respiration rate. As the only apparent trend was a general increase in the respiration rate as the time in storage increases (up to 5^{th} or 6^{th} day of treatment), and then it records more or less the same values (Table 3). As regarding the effect of MA treatments on fruit respiration rate; the lowest rate of respiration was obtained form fruits stored under the MA treatments that contained 0% O_2, but differences among MA treatments were not observed consistently. These findings are in harmony with some other similar works. Li and Kader , 1989,reported that the resultant effect of some combinations of high CO_2 and low O_2 atmospheres is synergistic. Plotto *et al.* (1999) reported that the commonly used storage atmospheres of 2 to 4 % O_2 and 5 to 7 % CO_2 suppress respiration and delay ripening of fruit, but such results cannot be achieved with either O_2 or CO_2 controlled atmospheres alone.

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Table 1: Influence of modified atmosphere storage treatments on weight loss of "Tristar" strawberry fruits after seven days of storage at different temperatures.

Treatments		Weight Loss (%)	
Oxygen (%)	Carbon dioxide (%)	2°C	21°C
1.5	0.0	3.8	49.2
3.5	0.0	2.4	51.9
0.0	15.0	4.0	2.9
0.0	25.0	2.1	2.8
1.5	15.0	2.5	47.7
1.5	25.0	2.1	26.5
3.5	15.0	1.7	53.5
3.5	25.0	1.8	38.7
Control (air)		2.1	51.4
MA LSD (0.05)		0.5	8.6

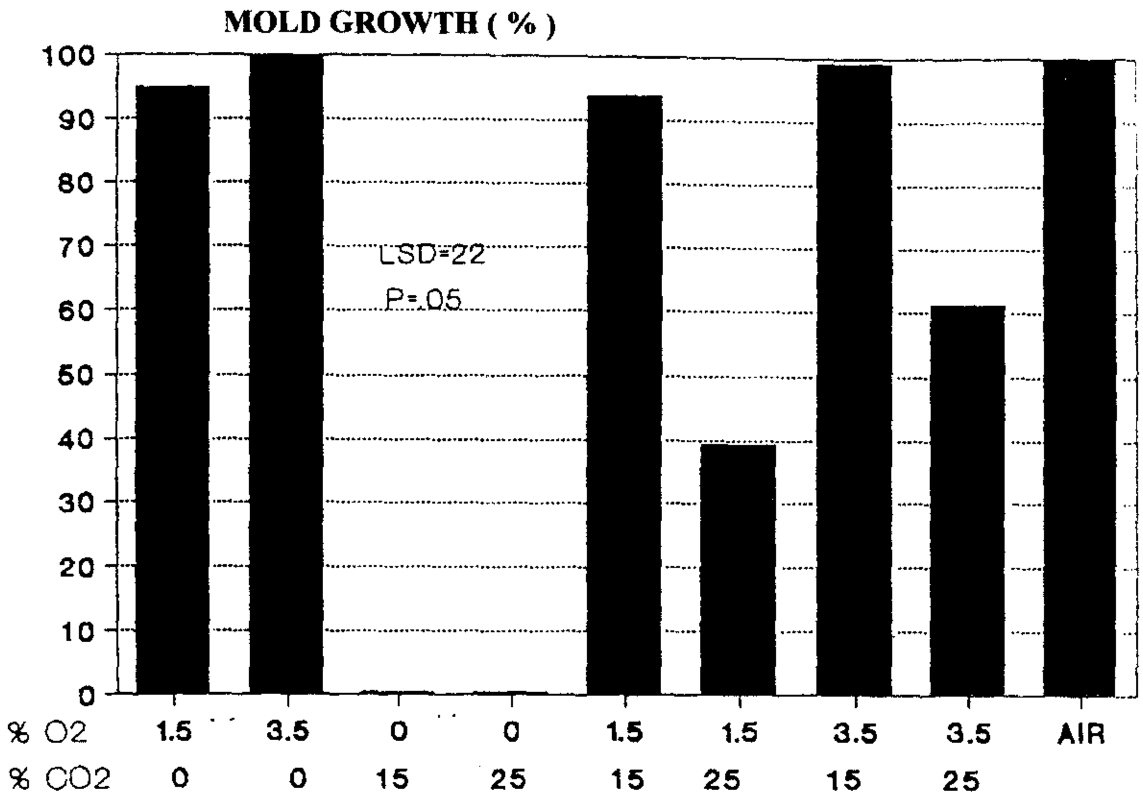

Figure 1 . Influence of modified atmosphere on the percentage of mold growth of ' Tristar ' strawberry after seven days of storage at 21°C .

Table 2 : Influence of modified atmosphere storage treatments on respiration rate (ml CO_2 / kg / hr) of ' Tristar strawberry during seven days of storage at 2°C .

Treatments		Days in storage					
O_2 %	CO_2 %	2	3	4	5	6	7
1.5	0.0	8.8	7.6	6.36	6.3	8.1	8.55
3.5	0.0	6.65	5.7	7.9	6.2	6.36	5.2
0.0	15.0	5.9	6.65	8.3	5.2	5.9	6.2
0.0	25.0	7.1	5.9	6.36	3.04	1.9	2.4
1.5	15.0	7.6	2.56	8.7	6.9	9.2	2.37
1.5	25.0	0.0	0.5	5.7	2.37	6.17	7.1
3.5	15.0	5.4	5.2	4.3	10.45	6.8	71
3.5	25.0	3.8	6.2	6.4	8.7	16.2	14.3
Air control		7.8	5.8	6.8	7.3	5.5	5.9
LSD 0.05		NS	NS	NS	NS	NS	NS

Table 3 : Influence of modified atmosphere storage treatments on respiration rate (ml CO_2 / kg / hr) of 'Tristar strawberry during seven days of storage at 21°C .

Treatments		Days in storage					
O_2 %	CO_2 %	2	3	4	5	6	7
1.5	0.0	15.2	27.6	49.4	61.8	46.6	31.4
3.5	0.0	23.8	23.2	60.8	46.6	38.0	39.9
0.0	15.0	10.5	9.0	5.9	7.3	11.4	9.2
0.0	25.0	8.3	3.5	8.1	11.4	9.5	15.2
1.5	15.0	31.4	18.1	24.7	33.3	36.1	40.9
1.5	25.0	17.1	24.7	17.1	23.8	33.3	32.3
3.5	15.0	12.4	20.0	20.9	47.5	38.0	31.4
3.5	25.0	9.0	16.2	9.5	10.5	31.4	23.8
Air control		19.0	48.5	57.0	52.3	58.0	58.0
LSD 0.05		14.01	NS	16.4	23.35	19.69	NS

تأثير المعاملة بالجو الغازي المعدل علي جودة الثمار و تقليل معدل التنفس في ثمار الفراولة صنف " تراى ستار "

خالد بن ناصر الرضيمان عبد الرحمن بن إبراهيم الحميد ضياء الدين الريس
جامعة الملك سعود-فرع القصيم-كلية الزراعة و الطب البيطري
قسم البساتين و الغابات – المملكة العربية السعودية

تم معاملة ثمار الفراولة صنف "تراى ستار" بثماني معاملات مختلفة من الجو الغازي المعدل حيث تم إستخدام تركيزات مختلفة من كل من غازي ثاني أكسيد الكربون و الأكسجين بالمعدلات الآتية :

1) 1.5 % O_2 2) 3.5% O_2 3) 25 % CO_2 4) 1.5%O_2+ 15% CO_2
5) 1.5% O_2 +25% CO_2 6) 3.5%O_2+ 15% CO_2 7) 3.5%O_2 + 25% CO_2

بالإضافة إلي الجو الغازي العا دى الذي أستخدم للمقارنة. و لقد تم حفظ الثمار المعاملة في درجات حرارة مختلفة، حيث حفظت إما في درجة حرارة الغرفة (21°C) أو تحت ظروف التخزين المبرد (2°C) و ذلك بهدف دراسة تأثير التركيبات المختلفة من الجو الغازي المعدل و كذلك تأثير درجات حرارة التخزين علي جودة ثمار الفراولة و معدل تنفسها. و لقد تم دراسة الصفات الطبيعية و الكيماوية للثمار و كذلك معدل تنفسها ، و كانت أهم النتائج المتحصل عليها ما يلي:

كانت أقل معدلات الفقد في وزن الثمار في المعاملات التي تم حفظها في درجات الحرارة المنخفضة (2°C) و التركيزات المرتفعة من غاز ثاني أكسيد الكربون (25%) مقارنة بثمار المقارنة. كما لم تلاحظ أي إصابات مرضية علي الثمار التي خزنت في درجات الحرارة المنخفضة (2°C) طوال فترة التخزين (٧ أيام) . أما الثمار التي حفظت في درجة حرارة الغرفة (21°C) فلقد تفاوتت درجة الإصابة بها . و كانت أقل نسبة إصابة في الثمار التي خزنت في الجو الغازي المعدل المركب من التركيبات الاتية: 1.5 % O_2 + 25 % CO_2 - 3.5 % O_2 + 25 % CO_2 و لقد أظهرت الثمار التي تم تخزينها في درجة حرارة الغرفة (21°C) علاقة طردية بين تركيز الأوكسجين في الوسط و معدل التنفس. كما أدت المعاملة بتركيزات الأوكسجين المنخفضة إلي تخفاض حاد في معدل التنفس بواسطة الثمار . و بصفة عامة فلقد إنخفض معدل التنفس بواسطة الثمار المخزنة في الجو الغازي المعدل مقارنة بتلك المخزنة في الجو الغازي العادي ، حيث كانت أقل معدلات التنفس في الثمار المخزنة في الجو الغازي المعدل المحتوي علي نسبة اوكسجين صفر%.