

CONTROLLED ATMOSPHERES RETARD SPROUT GROWTH, AFFECT COMPOSITIONAL CHANGES, AND MAINTAIN VISUAL QUALITY ATTRIBUTES OF GARLIC

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Abstract. Garlic storage is important to provide product for fresh market and fresh peeled processing. Garlic bulbs (cv. California Late) and unpeeled cloves were stored in several experiments in air and CA (0.1, 0.5, 1% O₂ in combination with 0, 5, 10, 15 and 20% CO₂) at 0-1°C for up to 6 months. Quality changes, especially sprout growth, decay and discoloration, were reduced by CO₂-containing atmospheres, but the low O₂ atmospheres alone generally had little benefit. Storage of garlic with CO₂ atmospheres >15% may lead to injury after 4-6 months. Fructan concentrations were similar among air and CA-stored bulbs, but notably decreased under 20% CO₂. Thiosulfinate and pyruvate concentrations were generally maintained in CO₂-containing atmospheres, but increased in air- and low O₂-stored garlic that permitted sprout development. Alliin concentrations were generally stable during storage up to 6 months, but in some cases decreased significantly under CO₂ atmospheres. For fresh peeled garlic, atmospheres of CO₂ (5-15%) in air or in low O₂ (1-3%) were effective in retarding discoloration and decay at 5 and 10°C for 3 weeks.

Keywords. *Allium sativum*, bulbs, peeled garlic, thiosulfinate, pyruvate, alliin

1. INTRODUCTION

Garlic is approximately 40% dry weight with the major complex carbohydrate being fructan with a small portion of free sugars. Garlic flavor is due to the formation of organosulfur compounds when the main odorless precursor, alliin (s-allyl cysteine sulfoxide), is converted by the enzyme alliinase. The main compound formed by this reaction is a thiosulfinate, allicin, compound responsible for the characteristic odor and flavor of fresh garlic (Block, 1985). The carbohydrate composition and pungency of garlic are quality parameters that have been little studied in relation to storage conditions. Garlic can be kept in good condition for 1-2 months at ambient temperatures under low RH (<75%). However under these conditions, bulbs will eventually become soft, spongy and shriveled due to water loss. For long-term storage, garlic is best maintained at temperatures of -1° to 0°C with low relative humidity (60-70%). Experience with CA storage of garlic is limited and the effect of CA on compositional changes has not been studied. Peeled garlic is one minimally processed product that has greatly increased in volume during the past few years (Cantwell and Suslow, 1999). Garlic variety, length of storage, and storage conditions may all affect the shelf life of the peeled product. For distribution of peeled garlic, information on quality changes under different storage temperatures and atmospheres is limited (Kang and Lee, 1999; Ramirez-Moreno et al., 2001).

2. EXPERIMENTAL

Garlic (cv. California Late or California Early) was field cured and then held at room temperature until establishing CA storage experiments. Outer cloves were peeled for determination of color, texture, dry weight and soluble solids. Samples were sliced and freeze-dried for determination of pyruvate and thiosulfinates by colorimetry, and carbohydrates and alliin by HPLC (Cantwell et al., 2001; Han et al, 1994; Hong et al, 1997).

Peeled garlic cloves were stored in containers through which humidified air flowed at 0, 5, 10 and 15°C or in controlled atmospheres at 5 and 10°C. Cloves were evaluated periodically for visual quality (5=excellent, 4=good, 3=fair, 2=poor and 1=unuseable), macroscopic decay and discoloration (1=none, 2=slight, 3=moderate, 4=moderately severe, 5=severe), aroma (5=typical, 1=none), color (LAB color values by Minolta color meter) and texture (rupture force with 2 mm blade on a TA-XT texture analyzer). Pungency was estimated by determination of pyruvate.

3. RESULTS AND DISCUSSION

3.1. CA storage of Garlic Bulbs

Atmospheres with high CO₂ (5-15%) were beneficial in retarding sprout development and decay during storage at 0-5°C (**Figure 1**). An O₂ concentration of 0.5% did not retard sprout development at 0°C, although lower O₂ concentrations (0.1-0.2%) retarded sprout growth in other experiments (data not shown). However, in another experiment (**Table 1**), a 1% O₂ atmosphere retarded sprout growth. Atmospheres with 15% CO₂ resulted in yellow translucent discoloration on some cloves after 4-6 months. Low O₂ atmospheres retarded the loss of fructan and increase in sugar, while high CO₂ levels (20%) resulted in decreased fructan and increased sugar concentrations (Table 1). CA did not significantly affect the alliin, thiosulfinate or pyruvate concentrations after 2 months at 0°C. Alliin concentrations were lower in CA-stored than air-stored garlic after 4 months (Table 1). In an experiment on another garlic cultivar (**Figure 2**), a CA with 10% CO₂ effectively retarded sprout development although 1% O₂ alone did not. Thiosulfinate concentrations were not significantly different among the atmospheres but did increase with storage time. Pyruvate concentrations were highest in air-stored garlic and CA significantly suppressed increases with time. The effects of CA on garlic composition were not entirely consistent and differences in initial physiological state of the garlic and the cultivar may affect the results. High CO₂ atmospheres were consistently effective in slowing sprout development regardless of the initial physiological state (internal sprout development).

3.2. Air and CA storage of Peeled Garlic

The main defects of commercially peeled and packaged garlic are discoloration and decay, and in cases of temperature abuse, sprouting and rooting. Discoloration and decay were mainly associated with mechanically damaged areas. At 0° and 5°C, excellent visual quality was maintained during >21 and 16 days of storage, respectively. At 10° and 15°C, acceptable quality was maintained for 12 and 8 days, respectively. Controlled atmospheres with 10% CO₂ in air or 1% O₂ notably affected peeled garlic quality by reducing decay and discoloration defects at 5° and 10°C. The benefit of CA was more apparent at 10° than at

5°C. Aroma of all peeled garlic samples decreased during storage and pungency (pyruvate concentrations) also generally decreased after 2-3 weeks. The following considerations are important to maintain the quality of fresh peeled garlic: 1) reduce mechanical injury during the peeling process; 2) store as near to 0°C as possible; 3) use modified atmospheres with 5-10% CO₂ to retard discoloration and decay in fresh peeled garlic stored at 5-10°C.

4. REFERENCES

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Table 1. Changes in composition of garlic (cv. California Late) stored 0, 2, and 4 months at 0-1°C under different controlled atmospheres. Experiment began when sprout development was near emergence from clove. All concentrations are expressed on a dry weight basis.

	Sprout Development	Fructan mg/g	Sugars mg/g	Alliin mg/g	Thiosulfinate mg/g	Pyruvate mg/g
0 time	1.04	786	0.67	26.8	79.1	171.0
2 months						
Air	1.25	732	0.68	28.0	79.8	166.3
1% O ₂	1.09	775	0.83	28.6	78.9	145.2
1% O ₂ + 10% CO ₂	1.06	743	1.03	27.5	75.7	146.5
Air + 10% CO ₂	1.11	739	1.06	27.1	79.7	161.3
Air + 20% CO ₂	1.06	636	1.51	25.5	78.5	155.9
4 months						
Air	1.53	638	0.63	27.9	89.5	180.6
1% O ₂	1.09	665	0.86	21.8	83.1	145.5
1% O ₂ + 10% CO ₂	1.08	685	1.17	20.9	78.8	129.1
Air + 10% CO ₂	1.14	657	1.26	23.2	83.2	168.6
Air + 20% CO ₂	1.10	492	2.15	22.1	80.7	164.1
LSD.05	0.08	54	0.11	1.6	1.7	9.1

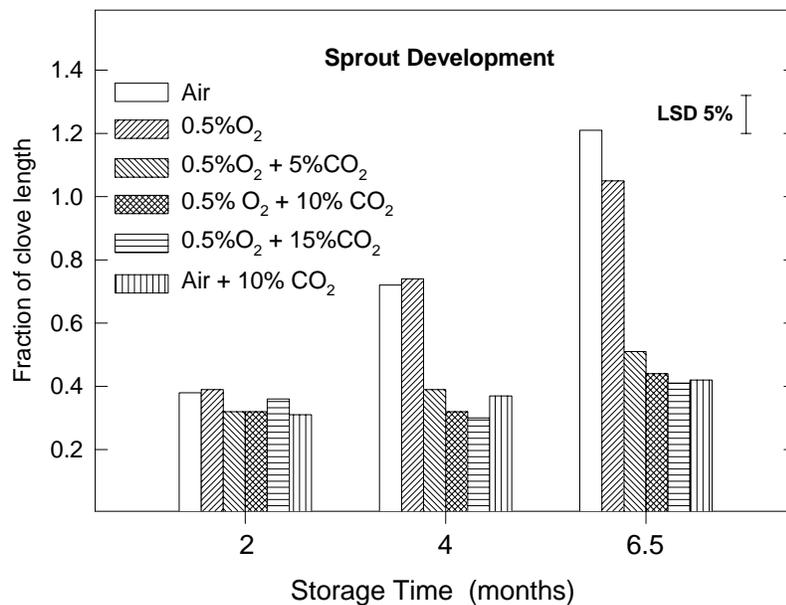


Figure 1. Sprout development of garlic (cv. California late) stored as intact bulbs at 0-1°C in air or controlled atmospheres. Initial sprout development was 0.1-0.2 of clove length.

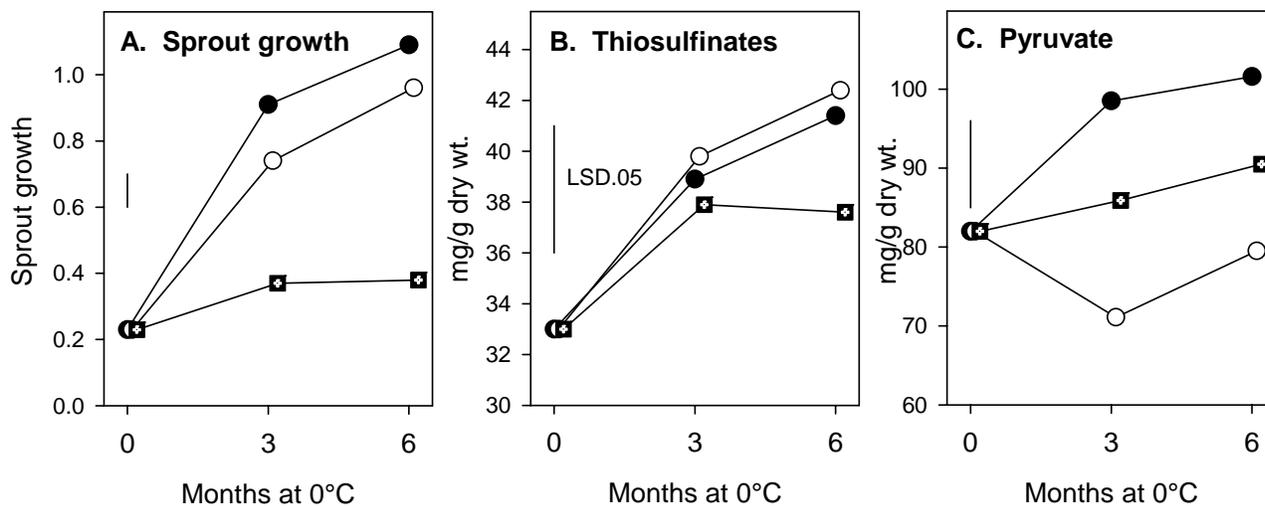


Figure 2. Sprout development and pyruvate and thiosulfinate concentrations of garlic (cv. California Early) stored at 0°C in air or controlled atmospheres.