Effect of Temperature and Low Oxygen Conditions on Respiration Rate and Qualities of Broad Bean (*Vicia faba var. major*)

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Abstract

Respiration rate, effect of temperature (5, 15 and 25 ºC) and controlled atmospheric condition (air and 2% O2) in broad bean were investigated. O2 consumption rate and CO2 production rate measured using flow through system. Respiration rate of the shelled seed is higher than the whole pod. A drastic increase of the CO2 production rate of the seed stored at 25 ºC was observed within 1 day after shelling. On the contrary, there was little increase in CO2 production of the seed stored at 5 and 15ºC. Some brown spots scattered on its seed coat was observed in the seed that kept at 15 ºC while it was dense occurred on the seeds stored at 25 ºC. The low oxygen condition, 2.1% O2, effectively reduced the yellowing of the shelled seed but was less effective on the reduction of browning. Data obtained from the respiration and quality evaluation on the broad bean seed indicated that storing shelled seeds at 5 and 15 ºC under the 2.1% O2 condition is able to maintain its good quality.

Key words: broad bean (*Vicia faba var. major*), respiration rate, low oxygen

INTRODUCTION

Convenience and health concern of nowadays consumers are the major reasons of the increasing demand on ready-to-eat and ready-to-use fruits and vegetables with like-fresh quality. In catering sections, they prefer to purchase minimally processed fruits and vegetables to reduce labour cost and hygiene problem. Minimal processing generally causes the stress on the produce. Change in rate of metabolic reaction, respiration, and other biochemical reactions cause deterioration occurrence. The colour, texture, flavour, and nutrition value are negatively changed. Therefore, shelf life of fresh produce is inversely proportional to respiration rate. Metabolism such as respiration and enzyme reaction in fruits and vegetables generally increases with an increase of temperature. Lowering the temperature of fruits and vegetables, lowering their rate of deterioration (Willis et al. 1998). Watada and Qi (1999) said that low oxygen levels are beneficial in retaining quality of fresh produce.

Broad bean (*Vicia faba var. major*) is a cool season crop. Seed is consumed as fresh vegetable or processed food. Due to the increase of its demand within Japan, the distribution for longer distance is requested. As the edible part of the broad bean is apparently low, approx. 30%, transportation cost including the non-edible
part and the waste accumulation to the urban area are becoming problems. Shelled seed distribution seems to be a solution. The objectives of this experiment are to investigate respiration rate of minimally processed broad bean and to study on the effect of temperature and low oxygen level on respiration rate and qualities of minimally processed broad bean.

MATERIALS AND METHODS

Broad bean grown in Chiba prefecture and some from Tsuchiura local wholesale market were used. They were stored at 5, 15, and 25 ºC under normal atmosphere and CA (low O₂). Respiration rates of whole pods and shelled seeds were measured by using flow through system. Under normal atmospheric condition, generated air from an air compressor was flushed at 400 ml/minute. The rates of oxygen consumption and carbon dioxide production were measured by automated computer controller gas analysis system (Shimadzu Corporation). Weight loss, seed colour, and sugar content were determined by means of an electronic balance, spectral calorimeter (MSC-IS-2D, Suga Instruments Co., Ltd.) and HPLC with refractive index detector (LC-10A, Shimadzu Corporation), respectively. To evaluate the sugar change, samples of pod shells and seeds were cut into small pieces, homogenized with 80% ethanol using homogenizer (Physcotron NS-51 at 13,000 rpm for 1 minute, centrifuged using Biofuge Primo, Hereaus at 4,000 rpm for 5 minutes and filtered through 0.2 μm filter (Ultrafree-MC, Millipore) before injection. Shim-pack SCR-101N column with water as a mobile phase is used for sucrose, glucose and fructose determination.

RESULTS AND DISCUSSION

Part 1 Whole pod and shelled seed stored under normal atmosphere at 5, 15, and 25 ºC

![Figure 1](attachment:image1.png)  
**Figure 1** Effect of temperature on respiration rate of broad bean whole pod and shelled seed under normal atmosphere.

The respiration rate of the shelled seed is higher than the whole pod and it is highest in the shelled seed stored at 25ºC (Figure 1). There is drastic increase of the respiration rate of the shelled seed at 25ºC within 1 day after shelling. On the contrary, there is little increase in the shelled seed under 5 and 15ºC.

The shelled seed stored at 25ºC shows the highest weight loss while the whole pod stored at 5ºC shows the least (Figure 2). According to the highest respiration rate at 25ºC the shelled seed has the highest sucrose reduction (Figure 3).

The appearance of the whole pod and the shelled seed after storing for 5 days. Some pods stored at 25ºC turned to brown or black color. There are more brown spots in the shelled seed stored at 25ºC and slight brown spots in the seed from pod stored at this temperature and in the shelled seed at 15ºC. The seed from pod at 15ºC has better appearance than the shelled seed at 5ºC. The best appearance is the seed from pod stored at 5ºC.
Part 2  Shelled seed stored under normal atmosphere and 2.1% O2 at 5, 15, and 25°C. 

2.2% O2 gas was introduced to the chamber which contained the shelled seeds under 5, 15, and 25°C. The outlet O2 was approx. 2.1% while the inlet O2 was 2.2%. Under the perfect mixing system, the gas concentration inside the chamber is considered to be the same as the outlet gas. Therefore, we considered that the O2 in the chamber was 2.1% (Figure 4). Respiration rate of shelled seed stored under low O2 condition reduced 40% of normal atmosphere at 5°C while at 15°C, it reduced 50%. At 25°C O2 consumption and CO2 production decreased 70% and 50%, respectively. Alcohol odour was observed in shelled seed stored at 25°C which had RQ more than 1.0.

In figure 5, it showed that the higher temperature, the more weight loss. 2.1%O2 can retard the reduction of sucrose (Figure 6) during 4-day storage. Figure 8 shows the appearance of the shelled seed after 4 days. Brown spots on seed and yellowness on seed without seed coat are seen in the shelled seed stored under normal air more than in seed stored under CA. From these observation, 2.1%O2 seems to be effective in reducing the yellowing of the seed but less effective on the reduction of brown spots.
Conclusion

Low temperature reduces the respiration rate of whole pod broad bean. Lower temperature is more effective to maintain the qualities of broad bean. Shelling increases the respiration rate and reduces the qualities of broad bean seed under high temperature. Low temperature in combination of low \( \text{O}_2 \) (2.1\%) decrease the respiration rate and retard the quality changes of broad bean seed. Storing shelled seed under 2.1\% \text{O}_2 condition at 5\(^\circ\)C is able to maintain its good qualities. The shelled seed stored at 15\(^\circ\)C under 2.1\% \text{O}_2 condition is acceptable for 2 days.

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References

