

ผลของอุณหภูมิและสภาวะออกซิเจนต่ำต่ออัตราการหายใจและคุณภาพของถั่วปากอ้า  
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 °C) and controlled atmospheric condition (air and 2% O<sub>2</sub>) in broad bean were investigated. O<sub>2</sub> consumption rate and CO<sub>2</sub> production rate measured using flow through system. Respiration rate of the shelled seed is higher than the whole pod. A drastic increase of the CO<sub>2</sub> production rate of the seed stored at 25°C was observed within 1 day after shelling. On the contrary, there was little increase in CO<sub>2</sub> production of the seed stored at 5 and 15°C. Some brown spots scattered on its seed coat was observed in the seed that kept at 15 °C while it was dense occurred on the seeds stored at 25 °C. The low oxygen condition, 2.1% O<sub>2</sub>, 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°C under the 2.1% O<sub>2</sub> condition is able to maintain its good quality.

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

บทคัดย่อ

การทดลองนี้ติดตามอัตราการหายใจของถั่วปากอ้า ผลของอุณหภูมิที่ 5 15 25°C และผลของสภาวะการเก็บที่ควบคุมบรรยากาศให้มีออกซิเจนประมาณ 2% โดยวัดอัตราการใช้ออกซิเจนและอัตราการผลิตคาร์บอนไดออกไซด์ด้วยระบบการให้ก๊าซไหลผ่านตลอดเวลา พบว่า เมล็ดถั่วที่แกะออกจากฝักมีอัตราการหายใจสูงกว่าถั่วทั้งฝัก อัตราการผลิตคาร์บอนไดออกไซด์เพิ่มสูงขึ้นอย่างมากในเมล็ดถั่วที่แกะแล้วเก็บที่อุณหภูมิ 25°C ในช่วง 1 วันหลังจากการแกะออกจากฝัก ส่วนอัตราการผลิตคาร์บอนไดออกไซด์ของเมล็ดถั่วที่แกะแล้วเก็บที่อุณหภูมิ 5 และ 15°C สูงขึ้นเล็กน้อย เมล็ดถั่วที่แกะแล้วเก็บที่อุณหภูมิ 15 °C มีจุดสีน้ำตาลกระจายอยู่บนเปลือกหุ้มเมล็ดน้อยกว่าในเมล็ดถั่วที่แกะแล้วเก็บที่อุณหภูมิ 25°C การเก็บภายใต้สภาวะบรรยากาศที่มีออกซิเจนต่ำ 2.1 % สามารถลดการเกิดสีเหลืองของเมล็ดถั่วที่แกะแล้วได้อย่างมีประสิทธิภาพ แต่มีผลเพียงเล็กน้อยต่อการลดการเกิดจุดสีน้ำตาล ข้อมูลจากการหายใจและการประเมินคุณภาพของเมล็ดถั่วชี้ให้เห็นว่า การเก็บเมล็ดถั่วปากอ้าที่แกะแล้วที่อุณหภูมิ 5 และ 15 °C ภายใต้สภาวะบรรยากาศที่มีออกซิเจน 2.1 % สามารถรักษาคุณภาพที่ดีของเมล็ดถั่วได้

**คำสำคัญ** ถั่วปากอ้า (*Vicia faba* var. *major*) อัตราการหายใจ ออกซิเจนต่ำ

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

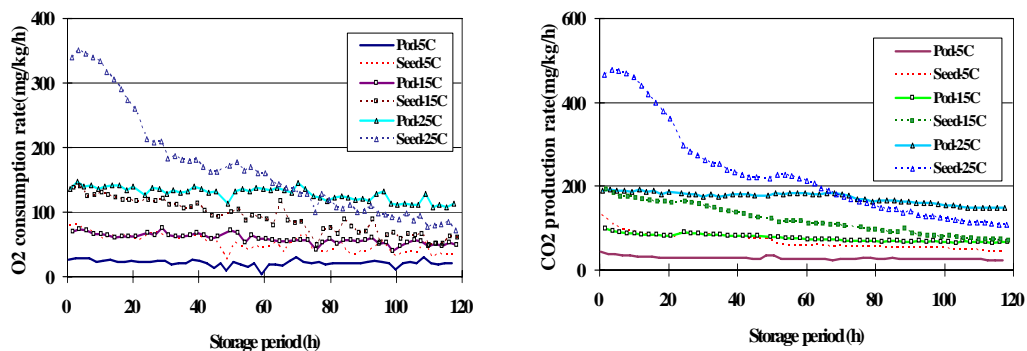
part and the waste accumulation to the urban area are becoming problems. Shelled seed distribution seems to be a solution. The objectives of this experiment are to investigate respiration rate of minimally processed broad bean and to study on the effect of temperature and low oxygen level on respiration 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 °C under normal atmosphere and CA (low O<sub>2</sub>). 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 (Phycotron 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 °C

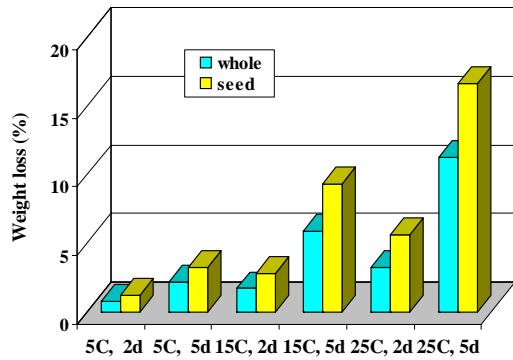


**Figure 1** Effect of temperature on respiration rate of broad bean whole pod and shelled seed under normal atmosphere.

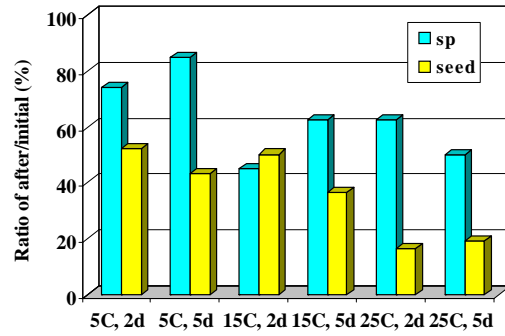
The respiration rate of the shelled seed is higher than the whole pod and it is highest in the shelled seed stored at 25°C (Figure 1). There is drastic increase of the respiration rate of the shelled seed at 25°C within 1 day after shelling. On the contrary, there is little increase in the shelled seed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

The shelled seed stored at 25°C shows the highest weight loss while the whole pod stored at 5°C shows the least (Figure 2). According to the highest respiration rate at 25°C 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 25°C turned to brown or black color. There are more brown spots in the shelled seed stored at 25°C and slight brown spots in the seed from pod stored at this temperature and in the shelled seed at 15°C. The seed from pod at 15°C has better appearance than the shelled seed at 5°C. The best appearance is the seed from pod stored at 5°C.



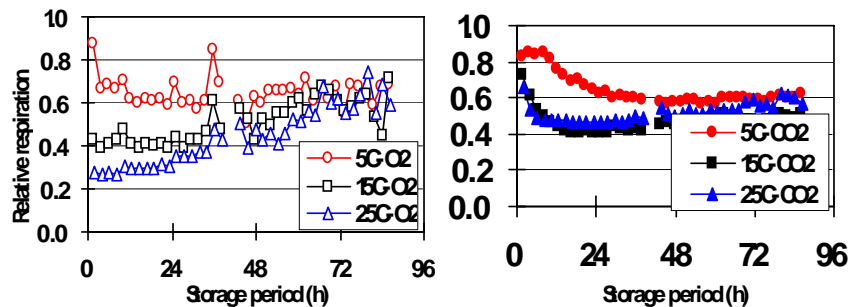
**Figure 2** Weight loss of BB seed and seed from pod (sp) after 2-day (2d) and 5-day (5d) storage.



**Figure 3** Sucrose change of BB seed and seed from pod (sp) after 2-day (2d) and 5-day (5d) storage.

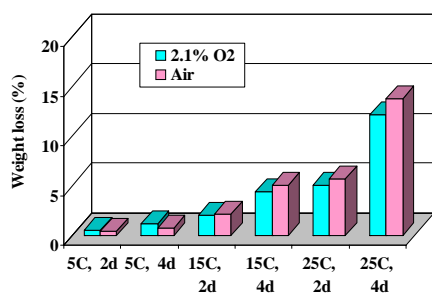
**Part 2** Shelled seed stored under normal atmosphere and 2.1% O<sub>2</sub> at 5, 15, and 25°C

2.2 % O<sub>2</sub> gas was introduced to the chamber which contained the shelled seeds under 5, 15, and 25 °C. The outlet O<sub>2</sub> was approx. 2.1% while the inlet O<sub>2</sub> 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 O<sub>2</sub> in the chamber was 2.1% (Figure 4). Respiration rate of shelled seed stored under low O<sub>2</sub> condition reduced 40% of normal atmosphere at 5°C while at 15°C, it reduced 50%. At 25°C O<sub>2</sub> consumption and CO<sub>2</sub> production decreased 70% and 50%, respectively. Alcohol odour was observed in shelled seed stored at 25°C which had RQ more than 1.0.

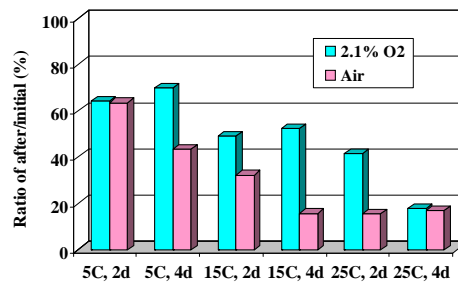


**Figure 4** Respiration quotient of broad bean seed stored under air and 2.1%O<sub>2</sub> at 5, 15, and 25°C.

In figure 5, it showed that the higher temperature, the more weight loss. 2.1%O<sub>2</sub> 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%O<sub>2</sub> seems to be effective in reducing the yellowing of the seed but less effective on the reduction of brown spots.



**Figure 5** Weight loss of BB seed after 2-day (2d) and 4-day (4d) storage under normal air and 2.1%O<sub>2</sub> at 5, 15, and 25°C.



**Figure 6** Sucrose change of BB seed after 2-day (2d) and 4-day (4d) storage.

### 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 O<sub>2</sub> (2.1%) decrease the respiration rate and retard the quality changes of broad bean seed. Storing shelled seed under 2.1% O<sub>2</sub> condition at 5°C is able to maintain its good qualities. The shelled seed stored at 15°C under 2.1% O<sub>2</sub> condition is acceptable for 2 days.

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