

Studies on Respiration Rate of Field Beans at Different Temperatures

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ABSTRACT

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Field bean also known as *Dolichos lablab* beans is one of the important legume crops grown widely in Southern Karnataka. It is rich in carbohydrate, protein, fat, and crude fiber. Fresh beans are a favoured vegetable of the people of this region. But, its availability is being seasonal, attempts are made to preserve its freshness for longer periods. The storage life of vegetables and fruits depends on their respiration rates. Respiration is a physiological process, involving the oxidation of the organic tissues evolving CO₂, water and energy. Hence studies were made to determine the respiration rate of field beans at different temperatures (24, 10 and 3°C). Experiments were conducted by storing 350g of field beans, in laboratory storage chambers of 1000ml capacity. Gas concentrations of CO₂ and O₂ were measured at regular intervals and respiration rates were computed. The results indicated that the respiration rates were 29.14, 53.17 and 85.15 mg CO₂/kg-h at 3, 10 and 24°C, respectively at the beginning of the experiment, which gradually decreased during the storage period. The rate of decrease of respiration rate was found to be low at lower temperatures.

Introduction

Field bean are bushy, perennial herb and semi-erect crop. It is mainly cultivated either as a pure crop or mixed with finger millet, groundnut, castor, corn bajra in Asia and Africa. The crop is mainly grown for pulse, vegetable and forage. The crop is grown for its green pod, while dry seed are used in various vegetable food preparations. It is one of the major source of protein in the diet in southern states of India. The consumer preference is mainly due to the pod fragrance. One of the cherished vegetable of south Karnataka people is field beans. It has a characteristic aroma of its own which is relished by the people. Field bean (*Dolichos lablab*) belonging to the family *Fabaceae*, is one of the most ancient legume crops.

It is a multipurpose crop grown for pulse, vegetable and forage. The crop is mainly grown for its green pods, while dry seeds are used in various vegetable food preparations. The beans are a good source of protein (24 %) carbohydrate (18 %) and starch (48 %) (Purseglove, 1968).

The fruits and vegetables lose their freshness when stored under ambient conditions, because of physiological and biochemical changes like transpiration and respiration. Respiration rate plays an important role in maintaining the freshness and quality of fruits and vegetables. The respiration rate can be controlled by reducing the temperature and / or gas compositions surrounding the product.

Temperature management is one of the most important tools for extending the shelf life of fruits (Lee and Kader, 2000).

Many studies on the effect of storage temperature on quality and storage life of fruits have been done which indicated that the temperature plays an important role on quality of fruits after harvest (Dixon *et al.*, 2004). Ripening is a complex physiological process that increases the softening, colouring, sweetening and aromatic compounds in most of the fruits and vegetables. The respiration is a metabolic process by which organic material in living cells are continuously broken down by utilizing O₂ and evolving CO₂, H₂O and energy. The metabolic reaction during respirations is shown below:



The metabolism of respiration may cause some physical/chemical changes such as weight loss, which reduce value of fruits and vegetables especially at room temperature (Khan & Ahmad, 2005). Different fruits and vegetables have different respiration rates. Respiration rate of fresh produce can be express as O₂ consumption rates. The storage life of commodities varies inversely with the rate of respiration. This is because of the reason that respiration supplies compounds that determine the rate of metabolic processes directly related to quality parameters such as firmness, sugar content, aroma, and flavor.

Commodities with higher rates of respiration tend to have shorter storage life than those with lower rates of respiration. Storage life of broccoli, lettuce, peas, spinach, and sweet corn, all of which have high respiration rates, is short in comparison to that of apples, cranberries, limes, onions, and potatoes, which have low respiration rates.

Materials and Methods

Materials

Fresh, well matured, Field beans (*Dolichos lablab*), were procured from Yelhanka market, Bengaluru which were available after 1 or 2 days of harvest. The pods were separated from the whole beans before the storage experiment. The physical dimensions like size, average weight and bulk density are measured for the samples selected for the respiration studies. For the respiration rate studies, experimental storage chambers consisted of PET jars of 1000 ml capacity with an airtight plastic lid. Teflon tape was wrapped around the mouth of the jars to seal the lids for air tightness.

Experimental set up

The respiration study was done to calculate the respiration rate of field beans as described by Bhukan Jyothi, (2008) and Ramachandra, (1995). The respiration rates of the field beans were measured at low (3 and 10 °C) and ambient (24 °C) temperatures. For the respiration rate studies, experimental storage chambers consisted of PET jars of 1000 ml capacity with an airtight plastic lid. Teflon tape was wrapped around the mouth of the jars to seal the lids for air tightness. A hole of 5 mm diameter was drilled on each of the lid and a septum (silicon rubber) was fixed firmly. The septum facilitated the insertion of the needle of the gas analyzer for measurement of gas concentration, inside the chamber. Field beans of known weight (350 g) were placed inside the experimental storage chambers with lids closed lids. Each set of three replications were placed in low (3 and 10 °C) and ambient temperature (24 °C). Beans were allowed to respire inside the experimental storage chambers, the gas concentrations inside the chambers were

measured using O₂ - CO₂ Gas Analyzer (Make: PBI Dan sensor, UK; Model: Checkmate II). The gas samples were drawn from zeroth hour and at every 30min. O₂ - CO₂ Gas Analyzer (Make: PBI Dan sensor, UK, Model: Check Mate II) is automatic and easy to use. When the syringe is introduced into the material package, the built-in pump automatically starts sampling the gas, ensuring an easy and accurate operation. The gas analysis result is shown in the built-in LCD display and also stored in the memory. The results can then be exported to an external computer via the USB data connection or saved on a memory stick, or printed on the built-in printer. The O₂ - CO₂ Analyzer, Check Mate II, consists of a zirconia (Zr) sensor (Fig. 2). The Zr sensor operates like a solid state battery which produces a small voltage or electro motive force (EMF) in the presence of oxygen.

$$RR = \frac{1.43 \times \text{head space concentration of O}_2 \times V \times 60}{w \times t \times 100} \quad (2)$$

$$RR = \frac{2 \times \text{head space concentration of CO}_2 \times V \times 60}{w \times t \times 100} \quad (3)$$

Where,

RR = Respiration rate, (mg O₂/ kg-h)

V = Free volume of the chamber (ml)

w = Mass of the stored product (kg)

t = Time (min), CO₂&O₂ = concentrations inside the chamber, (mg/l)

Results and Discussion

Physical properties

The Length 7.5- 13 mm, Width 3.4- 8.5 mm and Thickness 1.8- 5.6 mm. The shape of the

bean can be inferred as nearly oval as represented in the standard chart. The bulk density, true density and unit weight of the field beans (100 seeds), were 180.3±0.8 kg/m³, 360.5 ± 0.2 kg/m³ and 40 ± 6.5 g, respectively

Progression of O₂ and CO₂ concentrations (%) in the storage chambers

The variations of gas concentrations in airtight storage chambers are presented in table 1. The variations in gas concentrations are mainly due to the chemical reactions undergoing in the storage chambers. Results clearly indicated a fast depletion of O₂ and increase of CO₂ inside the closed chamber.

This trend was high at 24 °C compared to 10 and 3 °C. The CO₂ production rate and O₂ consumption rate has a great influence on temperature. At higher temperature CO₂ consumption was higher. According to Lakakul *et al.*, 1998 the increase in CO₂ concentration in the storage chamber jar will increase the heat which will enhance the rate of respiration. The O₂ consumption rate increased significantly with increase in the storage temperature inside the storage chambers with the field beans being stored. The reduction of O₂ and increase in the CO₂ will spoil the product quality due to the internal heat evolved from the tissues by the process of respiration, Yang *et al.*, (1988).

Respiration rates

The results clearly indicate that the respiration rate is dependent on the storage temperature, higher the temperature of storage higher the respiration rate. The O₂ and CO₂ concentrations were predicted from 0 to 69 hr for all experimental combinations. Using the equations (2) and (3) the respiration rate for the gas concentrations was calculated (Fig. 1).

Table.1 Gas Concentrations of Field beans stored in PET jars at temperatures 24, 10 and 3°C

Time (h)	Gas Concentrations of Field beans stored in PET jars					
	24°C		10°C		3°C	
	CO ₂ (%)	O ₂ (%)	CO ₂ (%)	O ₂ (%)	CO ₂ (%)	O ₂ (%)
0	0.00	20.10	0.00	20.10	0.00	20.10
3	0.04	19.5	0.05	19.50	0.04	20.02
6	6.0	12.4	3.80	16.50	1.08	19.30
9	10.0	1.6	4.90	15.22	2.50	19.00
12	11.3	1.49	5.08	14.70	2.56	18.80
15	12.6	1.38	5.20	14.40	2.62	18.70
18	13.9	1.27	5.50	14.00	2.68	18.70
21	15.2	1.16	5.80	13.80	2.74	18.70
24	16.5	1.05	6.10	13.20	2.80	18.60
27	18.0	0.99	6.40	13.50	2.86	18.65
30	25.0	0.35	6.70	12.10	2.92	18.40
33	30.0	0.35	7.00	10.01	3.50	18.12
36	32.0	0.29	7.30	9.10	3.89	18.10
39	34.0	0.28	7.60	9.20	3.92	17.80
42	36.0	0.27	7.90	9.50	3.98	17.60
45	38.0	0.26	8.20	9.70	4.19	17.58
48	55.0	0.25	8.10	9.80	4.26	17.10
51	65.0	0.28	8.40	9.98	4.50	16.90
54	65.6	0.16	8.70	8.67	4.80	16.80
57	66.2	0.13	10.20	8.20	5.10	16.70
60	66.8	0.12	10.27	8.10	5.40	16.60
63	67.4	0.11	10.34	8.50	5.70	16.50
66	68.0	0.11	10.50	8.80	6.00	16.50
69	69.0	0.12	10.78	7.10	6.20	16.50

Table.2 With the cubic model R² value indicated the best for 3°C temperature

Temperature (°C)	Gas Concentrations (%)	R ²
24°C	O ₂	0.873
	CO ₂	0.968
10°C	O ₂	0.951
	CO ₂	0.953
3°C	O ₂	0.966
	CO ₂	0.965

Table.3 Respiration rates of Field beans for 30min time interval in mg CO₂/ kg- h

Time (h)	RCO ₂ at 24°C	RCO ₂ at 10°C	RCO ₂ at 3°C
0	-	-	-
3	85.71	53.57	29.14
6	71.42	35.00	17.85
9	53.80	24.19	12.19
12	45.00	18.57	9.35
15	39.71	15.71	7.65
18	36.19	13.80	6.52
21	33.67	12.44	5.71
24	32.14	11.42	5.10
27	39.68	10.63	4.63
30	42.85	10.00	5.00
33	41.55	9.48	5.05
36	40.47	9.04	4.66
39	39.56	8.68	4.37
42	38.77	8.36	4.27
45	36.95	7.71	4.05
48	35.35	7.50	4.01
51	33.94	7.31	4.03
54	32.69	8.09	4.04
57	31.57	7.72	4.06
60	30.14	7.38	4.07
63	29.25	7.14	4.08
66	28.05	7.00	4.02
69	41.07	7.63	3.88

Fig.1 Storage chambers for respiration rate studies



Fig.2 O₂ and CO₂ Gas Analyzer



Fig.3 Influence of CO₂ concentration with respect to time at different temperatures (24, 10 and 3°C) on Field beans

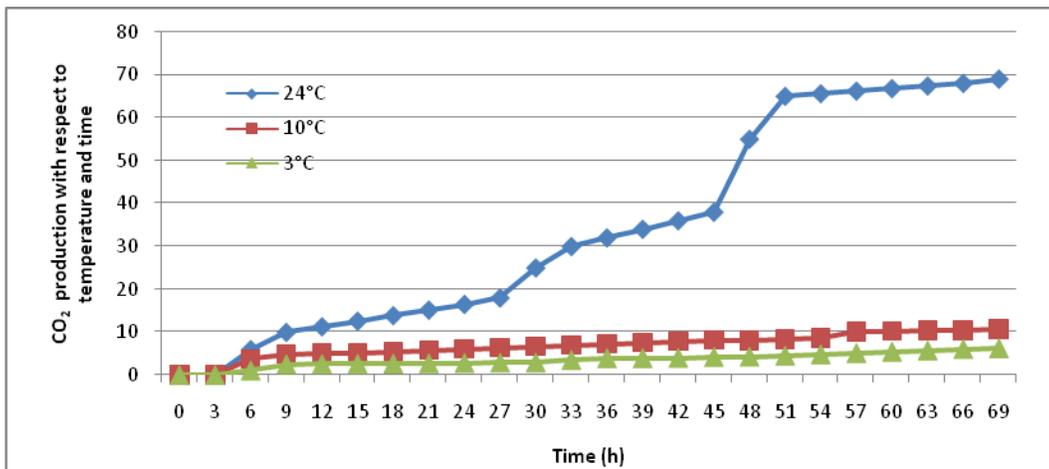


Fig.4 Influence of O₂ concentration with respect to time at different temperatures (24, 10 and 3°C) on Field beans

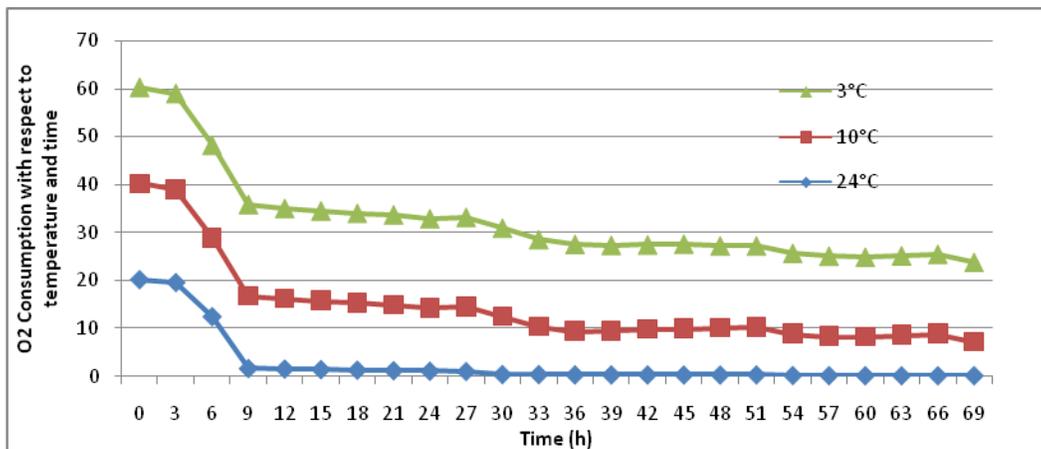
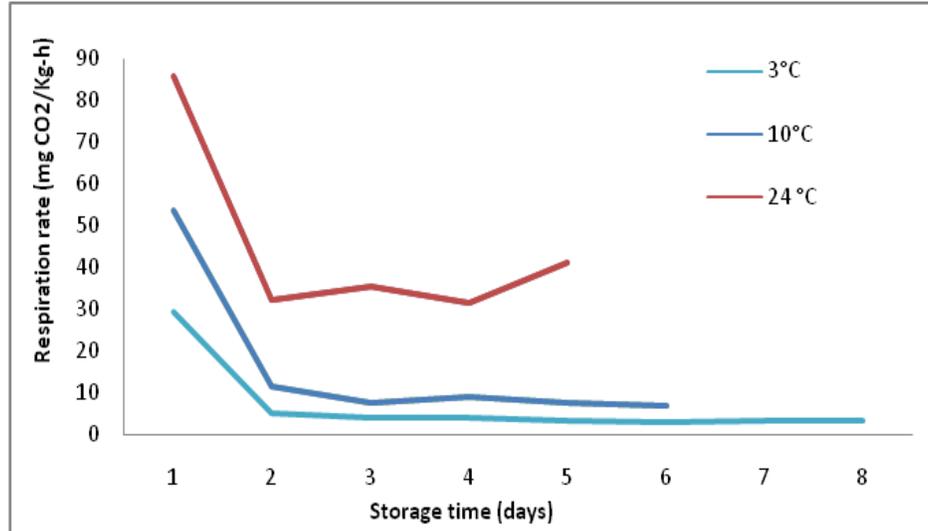


Fig.5 Respiration Rate of field beans in terms CO₂ concentration



From the values, it was observed that the respiration rates for CO₂ concentration at any temperature with increase in the time interval decreased. The CO₂ production rate was faster at 24°C than the other temperatures.

The reduction of respiration rates was noted at 10°C and 3°C. At 10°C there was a significant decrease of CO₂ production rate and at 3°C there were fluctuations in the CO₂ values which may be due to the occurrence of chilling injury of tissues. The respiration rate at different temperature is represented in figure 5.

From the result conclusion can be drawn that, the CO₂ release and O₂ consumption rates were faster during the initial hours of storage. It is clear that at 24 °C, the respiration rate of field beans gradually decreased after 30 hours (Figs 3 and 4). Such a decline may be due to the biochemical reactions taking place within in the substrate. At 10 and 3°C there was a gradual decrease in the respiration rate, which indicated that low temperature is helpful to slow down the respiration process and could keep the tissues alive for longer periods.

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