CRITICAL OXYGEN LEVEL FOR THE RESPIRATION OF MUSA SAPIENTANUM VARIETY GROS MICHEL*

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Different samples of bananas were separately exposed to a series of low oxygen concentrations of 0.5%, 1.0% and 2.5%. The rates of respiration exhibited by fruits exposed to 0.5% and 1.0% oxygen was greater than that in 2.5% oxygen during the first 50 hrs of the experiment. Qualitatively, however, all the three samples exhibited similar patterns of respiration. After this initial period, the rate of respiration in 0.5% and 1.0% oxygen became constant, whereas the rate of respiration of the fruit exposed to 2.5% oxygen gradually increased. The increased rate of respiration at sub-threshold oxygen levels (0.5% and 1.0%) was attributed to the combined effect of anaerobic and aerobic respiration. It was concluded that the "critical oxygen level" for the respiration of bananas was close to 2.5% oxygen and existed during the initial hours of the experiment alone.

Introduction

Low oxygen concentrations are used for retarding the respiration and ripening of fruits. Certain fruits respond typically to a 'critical oxygen level' below and above which there was an increase in the rate of respiration.[1] The increased rate of respiration at subcritical oxygen levels has been attributed to anaerobic respiration.

It is possible that prolonged storage of fruits in subcritical oxygen concentrations may result in the accumulation of toxic products due to incomplete oxidation. This may reduce the quality and storage life of fruits. Investigators have, therefore, determined the critical oxygen level for different fruits and vegetables, to avoid use of subcritical levels during storage. There has been no report available regarding the critical oxygen level for bananas.

Material and Method

Green Gros Michel bananas imported from Ecuador were used. The individual fingers were removed from the crown and washed. In order to reduce the growth of fungus, the cut portion of crown was treated with a paste containing 1% maneb. Fingers were randomly sampled from 4 to 6 different hands. Fruit samples weighing between 2.0 and 2.25 kg were kept in sealed desiccators. The desiccators were connected to cylinders having the desired composition of gases. The gas mixtures were prepared by introducing measured amounts of pure nitrogen and oxygen into cylinders which had previously been evacuated. Final analysis of the gas in the cylinders was carried out using an Orsat analyser having a 100-ml burette.

Preliminary experiments showed that a reduction in oxygen concentration from 21% to 5% did not significantly retard the rate of respiration, hence lower concentrations of 2.5%, 1.0% and 0.5% were used. A similar cylinder filled with air was used as a gas source for the control fruit.

Air from each desiccator was removed at the beginning of the experiment and a mercury manometer was attached to test for the leaks. The desired gas mixture from the cylinder was then flushed through the desiccator at a constant rate of 0.3 standard ft^3 per hr. Outflowing gas from the desiccator was collected in a 25-ml syringe and introduced in a gas chromatograph. The amount of carbon dioxide was determined using a thermal conductivity detector and an 8-in 60 to 80 mesh silica gel column. Initially, readings were taken every 2–3 hrs. Later, the rate of respiration did not show rapid fluctuations, therefore, two readings were taken every 24 hrs. The rate of respiration was determined on the basis of ml of CO_2 produced/hr/kg weight of fruit. The experiments were carried out in a growth chamber maintained at a constant temperature of 68°F. The results were verified by three separate replicates.

Results

The data from one of the experiments is given in Fig. 1. The following observations could be made from the trends of the graph.

(1) Bananas seem to have two clear-cut phases of respiration. During the initial phase (a period lasting up to 50 hrs) the pattern of respiration in the samples exposed to the three concentrations of oxygen was similar. Quantitatively however, the fruit exposed to 0.5% and 1.0% oxygen exhibited a rate of respiration greater than that in 2.5% oxygen.

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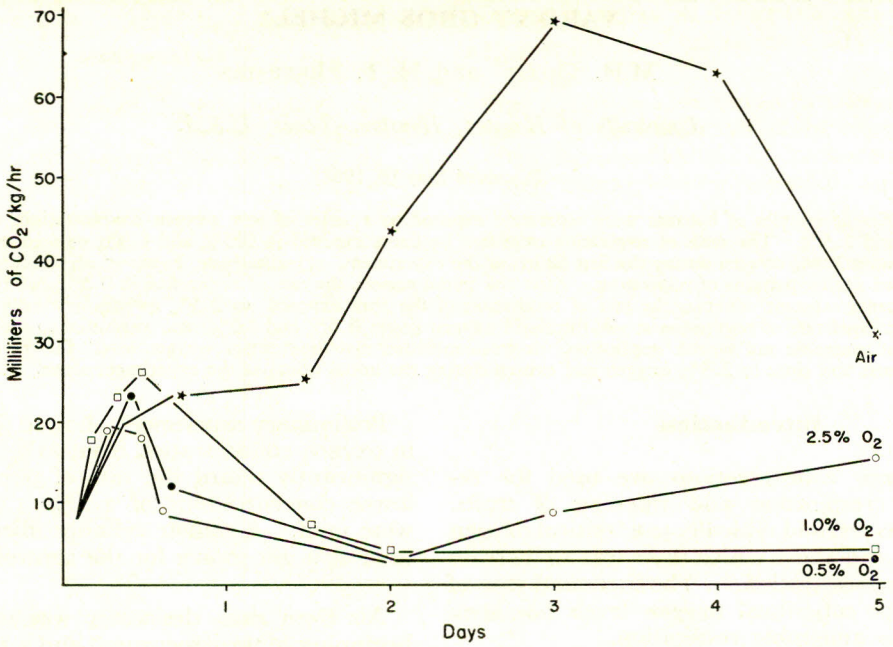

Fig. 1.—Evolution of CO_2 of bananas in gas mixtures.

(2) At the 50-hr period, the rate of respiration in all the three samples became equal. Afterwards the rate of respiration of the samples exposed to 0.5% and 1.0% remained constant whereas the sample exposed to 2.5% oxygen showed a steady increase in its respiratory rate.

(3) The control exhibited the normal pattern of respiration with the usual climacteric burst of respiration.

Discussion

An analysis of the figure shows that decreasing the oxygen level during the initial phase of the experiment did not cause a corresponding decrease in the respiratory activity of fruit. On the contrary, the rate of respiration exhibited by the samples exposed to 0.5% and 1.0% oxygen was greater than that in 2.5% oxygen. According to Blackman and Parija[2] the increased rate of respiration at subcritical oxygen levels may be due to the onset of some fermentative processes. It was postulated that above the "critical level" sufficient oxygen was present to maintain aerobic respiration and to suppress fermentation completely. At "subcritical levels" aerobic respiration probably did take place, but the rate of fermentation markedly increased. This combined output of the aerobic and anaerobic respiration was greater than that at the critical oxygen level. The increased rate of respiration in bananas exposed to 0.5% and 1.0% oxygen may also be attributed to the combined effect of aerobic and anaerobic respiration.

The respiratory patterns of the samples in the later phase of the experiment suggested that there existed a direct relationship between the oxygen and the rate of respiration. The control fruit exhibited the normal pattern of respiration with a climacteric burst. Lowering of oxygen level resulted in a corresponding decrease in the respiratory activity of fruit. In 2.5% oxygen the rate of respiration was considerably reduced, but it still exhibited a trend towards the climacteric rise in respiration. In the samples maintained in 1.0% and 0.5% oxygen the respiratory activity was further reduced and the climacteric rise was completely eliminated. The increased rate of respiration at low oxygen concentrations in the second phase of the experiment thus could not be observed even at 0.5% oxygen level. It can therefore be concluded that the "critical oxygen level" for the respiration of bananas was close to 2.5% oxygen and existed only for the initial phase of the experiment. The "critical oxygen levels" reported for other fruits and vegetables are: mangoes 9.2%,[4] spinach and snap beans 1%, asparagus 2.5%, peas and carrots 4%[3] and

lemons 5%.[1] The present value of 2.5% for bananas lies within the range of values reported for other fruits and vegetables.

It should also be mentioned that when the fruit was exposed to air at the termination of the experiment, it ripened in the normal manner without showing any signs of injury to its colour texture or flavour. This suggested that since the critical oxygen level existed for a short time, the accumulation of toxic end products of incomplete oxidation in banana were not large enough to injure the quality of fruit.

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