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STORAGE STUDIES ON KNOLKHOL BULBS USING DIFFUSION CHANNEL TECHNOLOGY

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ABSTRACT
Studies were conducted to extend the shelf-life of knolkhol using the diffusion channel technology. Diffusion channels of various lengths (5, 7.5 and 10 cm) and diameters (5, 7 and 9 mm) were used to determine the diffusivity of O_2 and CO_2 in the storage chambers. Diffusion channel with 5 cm length and 9 mm diameter was found superior in maintaining gas concentrations (5.58, 14.8 and 13.8%) O_2 and (23.5, 8.1 and 8.6%) CO_2 at 28, 10°C and 2°C temperatures, respectively.

KEY WORDS: Storage, Knolkhol, Diffusion channel, Length.

INTRODUCTION
Diffusion channel system is based on the principle of diffusion of gases through a channel. Diffusion channel is a channel or a tube of a specific diameter and length connecting a closed chamber to the atmosphere. Fick's first law of diffusion states that a species of gas diffuses in the direction of decreasing mole fraction of the same gas, just as heat flows by conduction in the direction of decreasing temperature (Bird, 1960). The commodity is stored in a closed chamber which is connected to ambient air through a diffusion channel (or tube). During the respiration of the commodity, O_2 is consumed and CO_2 is liberated resulting in the change of concentration of O_2 and CO_2 inside the chamber. The concentration of O_2 decreases and that of CO_2 increases with respect to ambient air at rates depending on the respiration rate of the produce. This creates concentration gradients through the channels. The steady state concentration levels of gases depend upon the type and mass of the commodity stored, respiration rate and the rate of diffusion of the gases. The rate of diffusion of gases depends upon the length and cross sectional area of the channel and the difference in concentration of O_2 and CO_2 between the chamber and the ambient air. The diffusion channel technique is used to maintain a steady state concentration of oxygen inside experimental chambers. It was observed that both the length and cross sectional area of the diffusion channel had significant effect on the final oxygen concentration (Ramachandra, 1995). The composition of oxygen in the storage chambers was regulated through the diffusion of oxygen in narrow channels (Ratti *et al.,* 1998).

METHODOLOGY
Diffusion Channel Storage
Fresh and uniform sized knolkhol bulbs were stored in PET (Polyethylene terephthalate) jars having diffusion channels. The PET jars were neatly washed with water and wiped with alcohol.

TABLE 1: Details of the treatments of diffusion channel storage system for storage studies of knolkhol bulbs

Treatments	Diameter of diffusion channel (mm)	Length of diffusion channel (cm)
T_1	5	5
T_2	5	7.5
T_3	5	10
T_4	7	5
T_5	7	7.5
T_6	7	10
T_7	9	5
T_8	9	7.5
T_9	9	10

The storage study with the above treatments was carried out at ambient (28°C) and low temperatures of 10°C and 2°C.

About 1.5 kg of knolkhol bulbs were placed in each PET jars along with 100 g of silica gel in perforated polythene covers to absorb the moisture released during storage. Teflon tape was wrapped around the mouth of the jar so that the screwed lid of the jar is made airtight. The diffusion channels were basically glass tubes of different inner diameters (5, 7 and 9 mm) and lengths (5, 7.5 and 10 cm) that were fixed vertically on the jar lids through a hole of corresponding diffusion channel diameter drilled through each lid. The tubes were left to protrude outside through the jar lid for exchange of gases with atmosphere. Septum was firmly fixed on one side of the lid with araldite to facilitate sampling of the gases inside the jars for analyzing O_2 and CO_2 concentrations. The PET jar so designed was airtight and had the visibility to assess the physical condition of the product during storage. The advantages of this design were ease of construction, perfect air tightness and durability. Gas concentrations were measured inside the storage chambers using O_2-CO_2 analyzer once a day to know the O_2 and CO_2 concentrations. The physical condition of bulbs was visually observed and the physiological loss of weight (PLW) was also measured during the storage period.

RESULTS & DISCUSSION

The results of studies on storage of knolkhol bulbs at different temperatures under different diffusion channels are presented below.

Effect of diffusion channels on headspace O_2 and CO_2 concentration at ambient temperature storage

The headspace gas concentration (O_2 and CO_2) in the storage containers (PET) with different diffusion channels during 6 days of ambient storage of knolkhol are presented in Fig. 1. It was observed that the level of O_2 inside the storage chambers progressively decreased from initial level of 21% to as low as <1% after 6 days of storage. For diffusion channel diameter of 5 mm, the O_2 concentration decreased to 1.91, 0.91 and 0.73%, respectively for channel lengths of 5, 7.5 and 10 cm. similar trends were observed for channel diameters of 7 and 9 mm.

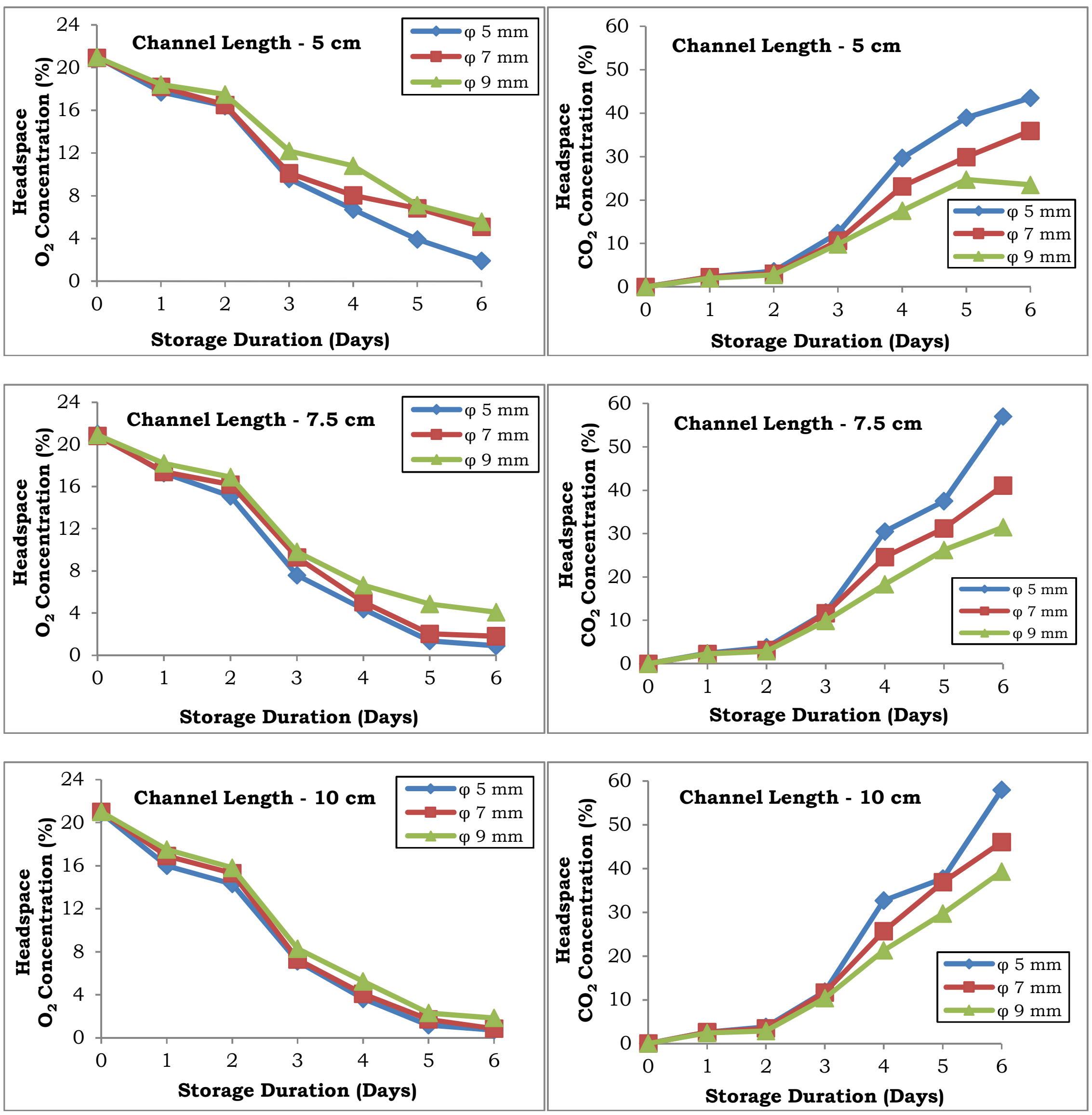

FIGURE 1: Headspace O2 and CO2 concentration in storage chambers with various diffusion channels during storage of knolkhol at ambient temperature (28°C)

Effect of diffusion channels on headspace O_2 and CO_2 concentration at storage temperature of 10°C

The concentration of CO_2 in the storage chambers of knolkhol with different dimensions of diffusion channels was initially slow for about 2 days and then it steadily increased with progressive storage period reaching a very high CO_2 concentration of over 55% in some treatments. For the diffusion channel diameter of 5 mm, the peak CO_2 levels inside the storage containers were 43.5, 57 and 58% (after 6 days) respectively with the channel lengths of 5, 7.5 and 10 cm. Similar trends were observed for channel diameters of 7 and 9 mm.

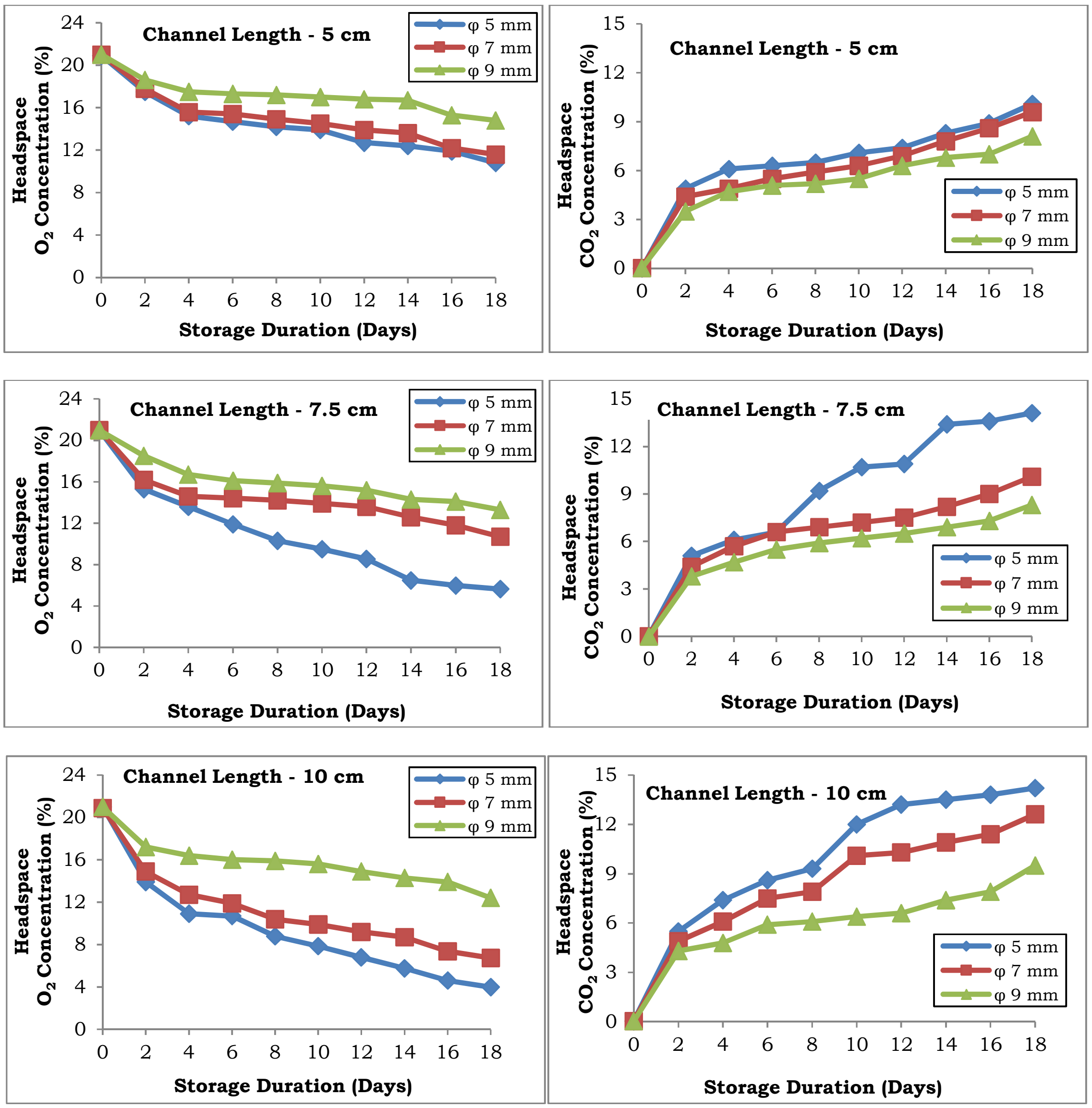

FIGURE 2: Headspace O_2 and CO_2 concentration in storage chambers with various diffusion channels during storage of knolkhol at 10°C temperature

At 10°C storage temperature, the changes in the headspace gas concentration (O_2 and CO_2) in storage containers (PET) with different diffusion channels during 18 days of storage of knolkhol are presented in Fig.2. For diffusion channel diameter of 5 mm, the O_2 concentration decreased to 10.8, 5.64 and 3.98%, respectively for channel lengths of 5, 7.5 and 10 cm. Similar trends were observed for channel diameters of 7 and 9 mm. The concentration of CO_2 in the storage chambers of knolkhol with different dimensions of diffusion channels was initially slow and then it steadily increased with progressive storage period reaching a CO_2 concentration of over 14% in treatments T_2 and T_3. For the diffusion channel diameter of 5 mm, the peak CO_2 levels inside the storage containers were 10.1, 14.1 and 14.2% (after 18 days) respectively with the channel lengths of 5, 7.5 and 10 cm. Similar trends were observed for channel diameters of 7 and 9 mm.

Effect of diffusion channels on headspace O_2 and CO_2 concentration at storage temperature of 2°C

The O_2 and CO_2 concentrations of knolkhol bulbs stored in the storage containers (PET) with different diffusion channels kept at 2°C were periodically measured and data recorded are presented in Fig.3. From the results, it was observed that the level of O_2 inside the storage chambers progressively decreased from initial level (21% to about 5%) after 24 days of storage. For diffusion channel diameter of 5 mm, the O_2 concentration decreased to 6.93, 6.73 and 4.8%, respectively for channel lengths of 5, 7.5 and 10 cm similar trends were observed for channel diameters of 7 and 9 mm.

The concentration of CO_2 in the storage chambers of knolkhol with different dimensions of diffusion channels was initially very slow and then it steadily increased with progressive storage period reaching a CO_2 concentration of 15% in T_3 treatment. For the diffusion channel diameter of 5 mm, the peak CO_2 levels inside the storage containers were12.2, 13.9 and 15.1% (after 24 days) respectively with the channel lengths of 5, 7.5 and 10 cm. Similar trends were observed for channel diameters of 7 and 9 mm.

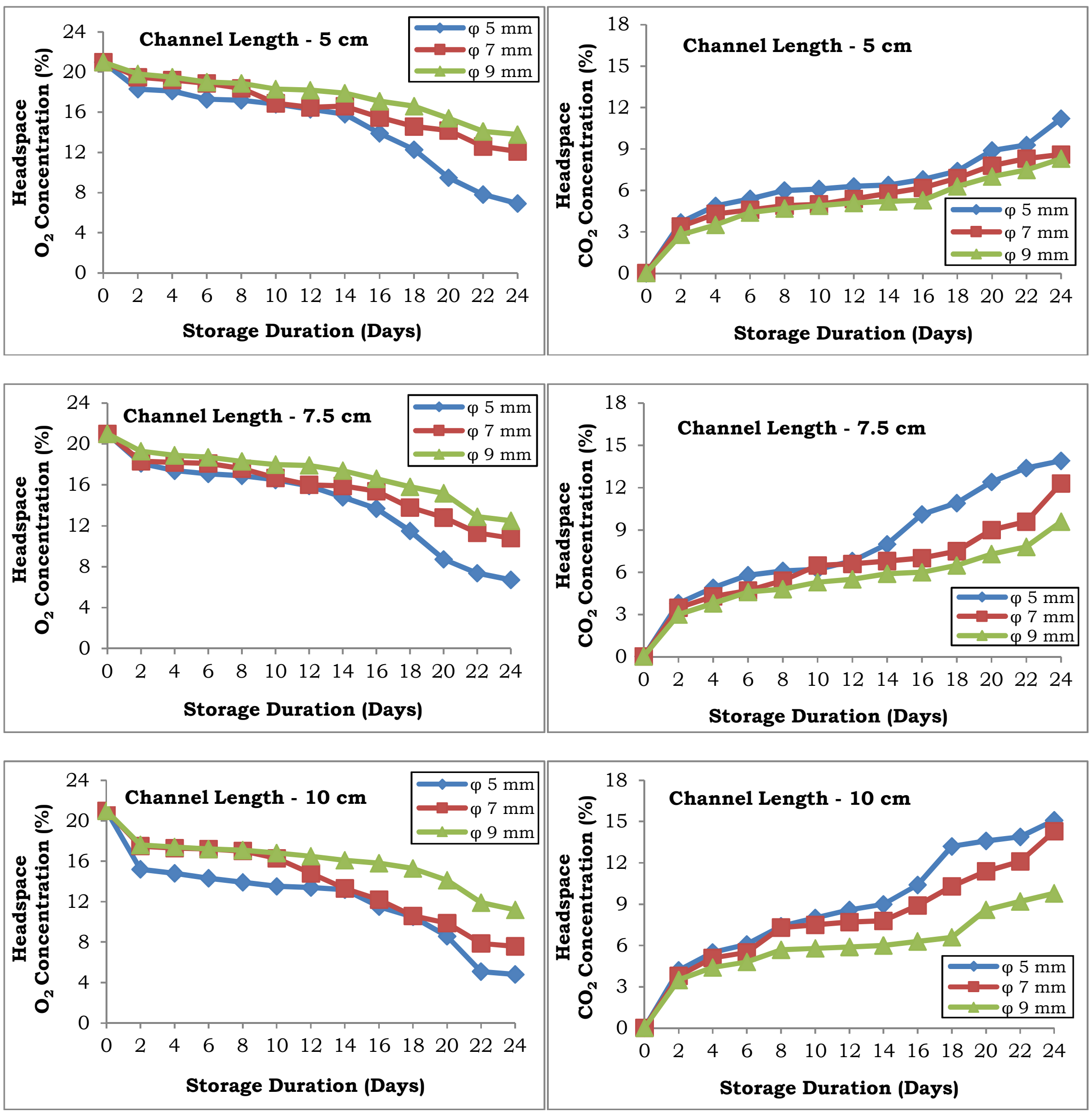

FIGURE 3: Headspace O_2 and CO_2 concentration in storage chambers with various diffusion channels during storage of knolkhol at 2°C temperature`

From the above results, it was clear that at a given period of storage, the concentration of CO_2 was less at 2°C and 10°C compared to ambient temperature which could be attributed to the lower rate of respiration. Any change in temperature affected the rate of respiration and the equilibrium conditions within the package unless the rate of diffusion of gases through the package was changed by the temperature to exactly the same extent as respiration (Kader *et al.*, 1989).

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