# EXTENSION OF THE SHELF LIFE OF BREADFRUIT (ARTOCARPUS ALTILIS) BY DIFFUSION CHANNEL SYSTEM

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## ABSTRACT
The potential of the diffusion channel system to extend the shelf life of breadfruit (*Artocarpus altilis*) was evaluated. Breadfruits were stored at regular atmosphere (RA) and controlled atmosphere (CA) using diffusion channel system for 5 days at 25 $^{o}$C. Fruits stored at RA ripened, showed increased production of ethylene and colour change from green to yellow. Fruits stored at CA on the other hand, did not ripen, showed reduced production of ethylene and no colour change from green to yellow. Controlled atmosphere using diffusion channel, provides an inexpensive and easy way of extending the shelf life of breadfruits, in order to reduce wastage and enhanced food security.

**Key words:** Controlled atmosphere, storage, breadfruit, *Artocarpus altilis*, diffusion channel, regular atmosphere.

## INTRODUCTION
Breadfruit (*Artocarpus altilis*) is a seedless, starchy, tropical fruit, belonging to the Moraceae family and native to the Pacific Islands and tropical Asia**.** The breadfruit is now a very important staple food, not only in the Pacific Islands and Southeast Asia, but also in the West Indies and South America (Worrell *et al.*, 2002; Golden and Williams, 2007). There are other species of *Artocarpus*, which contain edible seeds that are also cultivated locally in the tropics; in Nigeria (West Africa), a variety known as ukwa bekee is cultivated and consumed locally for its edible seeds (Okorie, 2010).

A variety of nutritious and delicious dishes can be prepared form the breadfruit (*Artocarpus altilis*). The Mature unripe or ripe breadfruits can be steamed, boiled, roasted, grilled, fried and consumed in much the same way as tubers; while breadfruit flour that is used to prepare porridge can also be made from the unripe fruit (Worrell and Carrington, 1997). Breadfruit (*Artocarpus altilis*) has also been categorized as a low - glycemic index food and as such could be used to obtain a good glycemic control (Widanagamage *et al.*, 2009). Although, most breadfruits are consumed locally, there is a growing export form the Caribbean to Europe and the North America. Breadfruits ripen very quickly, having short shelf life and are highly perishable, thus making their export difficult (Worrell *et al.*, 1998; Williams, 2002). Refrigeration tends to slow the ripening process for some few days but results in drying and hardening of the internal flesh (Williams, 2002).

The aim of this present study was to determine the potential of diffusion channel system to provide suitable conditions for optimum storage of breadfruits in order to enhance their shelf life, reduce wastage, provide food security and also make their exportation easy.

## MATERIALS AND METHODS
### Plant material
Mature, green, unripe breadfruits *(Artocarpus altilis*), were obtained from a local market in Papine, St. Andrew, Jamaica. Breadfruits (1,112 g) were weighed and placed in each laboratory scale storage chamber (experimental chamber). Fruits were stored at 25 $^{o}$C for five days

### Experimental chambers
The laboratory scale storage chambers (Figure 1) were composed of a length of PVC pipe, 30

cm long and 17 cm internal diameter. The extremities of each unit were fitted with a square sheet of acrylic 5 mm thick, held in place by threaded rods. At one end of the chamber, the acrylic lid served as a cover and was removable to facilitate opening and closing of the chamber. The cover was transparent, allowing for visual fruit inspection during storage. Diffusion channel tube of length 4 cm and 2 mm internal diameter was installed onto the acrylic cover of one of the chambers in order to control the oxygen (Gariépy *et al*., 1986; Ramachandra, 1995; Ratti *et al*., 1997; Stewart *et al*., 2005). Neoprene gaskets were used at both ends of the chamber to ensure air tightness. The control chamber was not fitted with diffusion channel tube. The gas concentration in the sealed chamber with the diffusion channel tube was established by flushing the container with 100% $N_2$ and allowing the atmosphere within the chamber to be modified by the diffusion channel system. The control chamber contained the regular atmosphere (RA), while the chamber with the diffusion channel contained controlled atmosphere (CA). The final oxygen concentration of the controlled atmosphere (CA) was 5%; this was determined by the Hewlett Packard gas chromatograph fitted with a thermal conductivity detector.

*(a)* *(b)*

***Figure 1.*** *Laboratory scale storage chambers (experimental chambers).*

a) *Chamber containing Regular Atmosphere (RA).*
b) *Chamber containing Controlled Atmosphere with diffusion channel (CA).*

**Measurement of ethylene**

Ethylene produced by the breadfruits at regular atmosphere (RA) and controlled atmosphere (CA) was measured using a Pye Unicam series 204 Gas Chromatograph (GC), fitted with a flame ionization detector. The flame ionization detector was coupled to a column [column dimensions: 6 mm (o.d.) × 4 mm (i.d.) × 1.5 m] containing alumina packing (F-1 80/100 mesh). The results were recorded by a Philips pu 4810 integrator. Two gas samples of 1 ml each were taken from each storage chamber and injected onto the GC. The GC parameters were: injector temperature 120°C; detector temperature 200°C; oven temperature 75°C; sensitivity 4 × 10; carrier gas $N_2$; flow rate through the column was 30 ml $min^{-1}$. The amount of ethylene produced was quantified using the method of Lizada and Yang (1979), in which 1 – amino cyclopropane -1- carboxylic acid (ACC) was quantitatively converted to ethylene and a standard curve for ethylene was generated.

**RESULTS AND DISCUSSION**

Plant hormone, ethylene ($C_2H_4$) triggers ripening in fruits. The ripening period in climacteric fruits such as breadfruit, is associated with various biochemical and physiological processes such as enhanced evolution of ethylene, intense respiratory activity (climacteric rise), colour changes and textural changes due to softening (Thompson and Burden, 1995; John and Marchal, 1995).

Ethylene biosynthetic pathway in plants, which is also known as the Yang pathway; converts the amino acid methionine (Met), to S – adenosyl methionine (SAM or AdoMet) by the enzyme S – adenosyl methionine transferase. SAM is converted by the enzyme 1 – amino cyclopropane – 1 – carboxylic acid synthase (ACC synthase) to 5' – methylthioadenosine and 1 – amino cyclopropane – 1 – carboxylic acid (ACC), which is the precursor of ethylene. ACC is finally oxidized to ethylene by the enzyme, 1 – amino cyclopropane – 1 – carboxylic acid oxidase (AAC oxidase) (Zarembinski and Theologis, 1994; Bleecker and Kende, 2000; Wang *et al*., 2002). Increase biosynthesis of ethylene during ripening results in enhanced evolution of ethylene due to its massive production (Liu *et al*., 1999). Breadfruits stored at regular atmosphere (RA) where ripening occurred in this study also showed increased evolution of ethylene (Figures. 2 and 3). On the other hand, breadfruits stored at controlled atmosphere with diffusion channel (CA); where ripening did not take place, showed reduced evolution of ethylene compared to that of regular atmosphere (Figures 2 and 3).

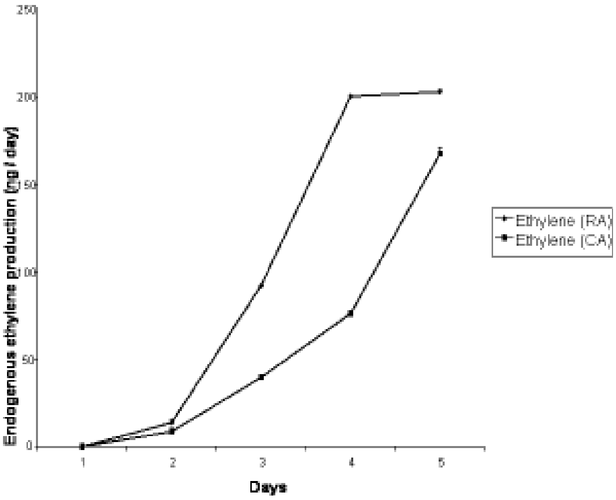


***Figure 2.*** *Endogenous ethylene production in intact breadfruit at Regular Atmosphere (RA) and Controlled Atmosphere with diffusion channel (CA). Values represent Mean ± SEM (n = 2).*

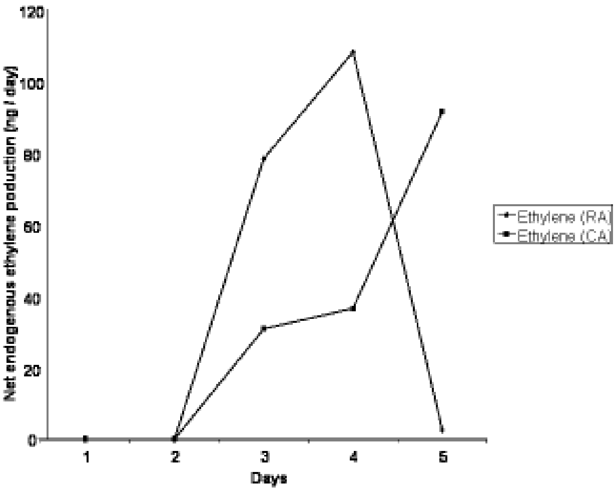


***Figure 3.*** *Net endogenous ethylene production in intact breadfruit at Regular Atmosphere (RA) and Controlled Atmosphere with diffusion channel (CA).*

During respiration, oxygen is used to release the energy stored in carbon compounds in a controlled manner for cellular use and at the same time to generate many carbon precursors for biosynthesis (Taiz and Zeiger, 2002). At the preclimacteric phase (which is also known as the green life, when the fruit is still unripe), the respiration rate of the fruit is low, but at the onset of ripening, there is a marked rise in respiration known as the climacteric rise. This intense respiratory activity (climacteric rise), that is associated with the ripening phase is triggered by the endogenous production of ethylene (Biale, 1980; Taiz and Zeiger, 2002). Shortly before the climacteric rise begins, there is an increase in ethylene evolution. Turner (2001) has reported that the peak in ethylene evolution occurs when the respiration rate is increasing rapidly due to ripening. In this study, breadfruits stored at regular atmosphere (RA) that had normal atmospheric oxygen (21%), which sustained intense respiratory activity, showed a peak in ethylene evolution (Figure 3) and also ripened (Figure 4). The breadfruits which were stored at controlled atmosphere with diffusion channel (CA) that had reduced oxygen concentration (5%), sustained less intense respiratory activity, did not show a peak in ethylene evolution (Figure 3) and also did not ripen (Figure 5). Brady (1987) also suggested that the increase in respiration is the consequence of the increased synthesis of endogenous ethylene.

The change in colour from green to yellow is one of the characteristics of ripening that is most obvious to a casual observer. This colour change is due largely to the destruction of chlorophyll which unmasks the carotenoids present in the unripe fruit (Yamauchi *et al*., 1997). Breadfruits stored at regular atmosphere in this study, where ripening took place, showed the colour change from green to yellow (Figure 4).

***Figure 4.*** *Breadfruit sample stored at Regular Atmosphere (RA).*

At the same time, the breadfruits stored at controlled atmosphere with diffusion channel, where ripening did not occur; showed no colour change from green to yellow, it remained green (Figure 5).

***Figure 5.*** *Breadfruit sample stored at Controlled Atmosphere with diffusion channel (CA).*

The partial disassemblies of the fruits' cell walls that occur during ripening in fruits are largely responsible for softening and textural changes. As ripening progresses in these fruits, the cell walls become increasingly hydrated as the pectin rich middle lamella are modified and partially hydrolysed, leading to changes in their cohesion. These ripening associated changes in the cohesion of the pectin gel are very important determinants of the textural changes in these fruits (Huber, 1983a; Huber, 1984; Gross *et al*., 1986; McCollum *et al*., 1989). These apparent changes in cell walls that accompany fruit ripening, implicate the action of cell wall degrading enzymes, such as polygalacturonase, pectin methylesterase, galactosidase and expansin, which are capable of degrading specific cell wall components (Huber, 1983b; Carpita and Gibeaut, 1993; Brummell and Harpster, 2001; Alexander and Grierson, 2002; Wang *et al*., 2005).Textural changes due to softening were observed in breadfruits stored at regular atmosphere, where ripening occurred in this study. On the other hand textural changes due to softening were not observed in breadfruits stored at controlled atmosphere with diffusion channel, where ripening did not take place in this study.

## CONCLUSION

Controlled atmosphere (CA) storage of breadfruits with diffusion channel system in this study lowered the percentage oxygen that was available to the fruits and resulted in reduced endogenous ethylene production, delayed ripening and extended shelf – life. This CA system can be enhanced in order to further prolong the shelf life of the fruits. The controlled atmosphere (CA) with diffusion channel used in this study also provides an inexpensive alternative to the complex systems that are usually associated with CA systems.

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