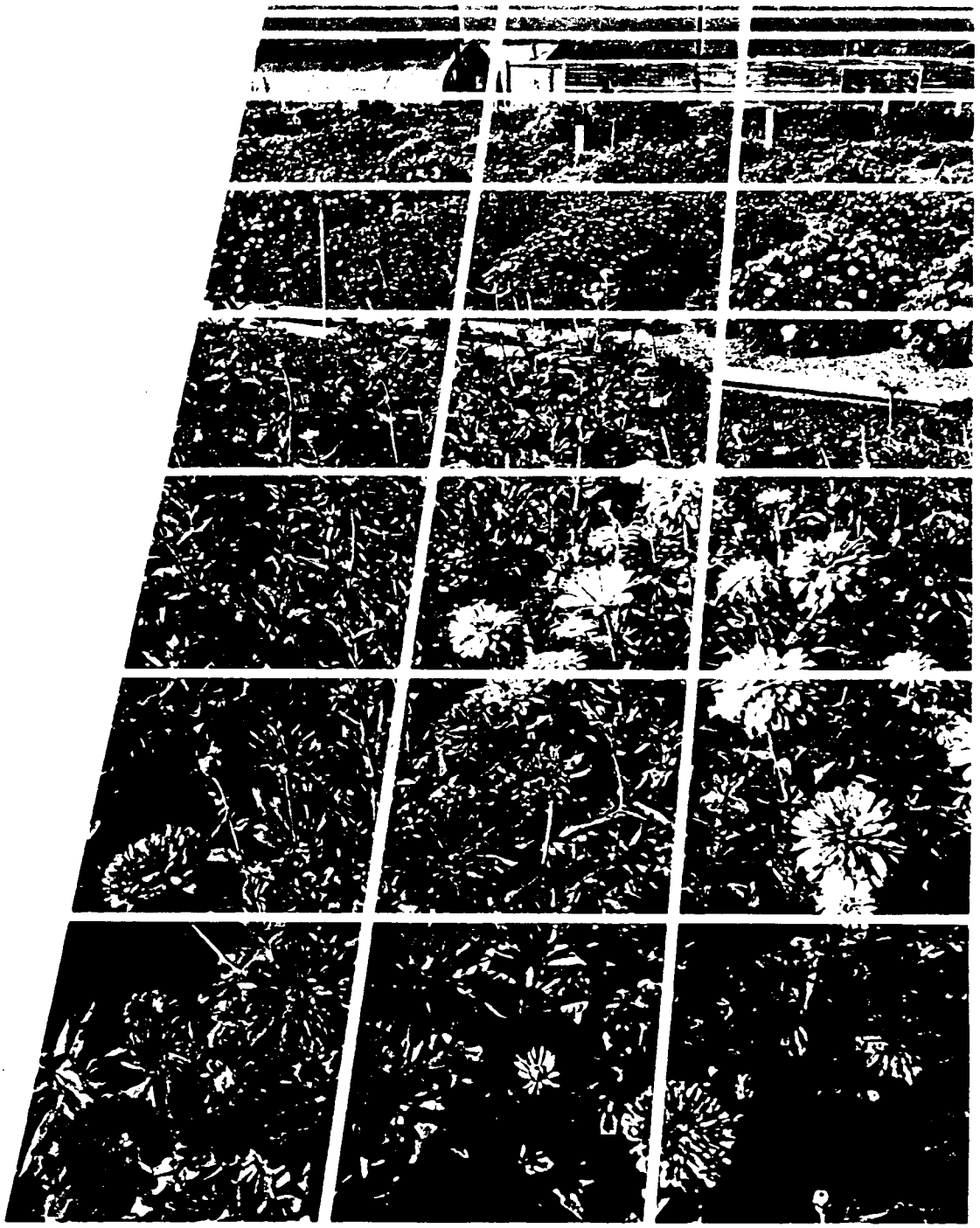

Research Perspectives

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Processing

Fresh cucumbers for commercial pickling are available only in the summer and early fall months in North Carolina. About one-half of the crop is processed into "fresh-pack" pickles soon after harvest. The other half of the crop is placed in large (e.g., 10,000 gal) tanks along with a salt solution, as a means of temporary storage of the cucumbers until they are needed for further processing into various types of sweet and sour products. During brine storage, the cucumbers undergo fermentation to yield pickle products with flavor, texture, and appearance distinct from fresh-pack pickles. In contrast to fresh-pack pickles, the brined product requires little, if any, heat processing if properly done. Thus, brining offers several advantages in the preservation of cucumbers and certain other vegetables. Those include: a means for rapid, temporary storage; distribution of labor and equipment needs throughout the year; and low-energy requirements for processing. Brine storage is not without problems, however.

Damage Due to Gas

A major problem encountered during brine storage of cucumbers is a defect known as bloater damage. This is a gaseous hollow which forms in the flesh of brine-stored fruit. The problem is more serious in large than in small cucumbers. Carbon dioxide, formed during the fermentation, accumulates in the fruit and causes bloating.

Over a decade ago, the U.S. Food Fermentation Laboratory introduced to the pickle industry a process known as nitrogen purging. This consists of bubbling nitrogen gas through the brine to sweep away the carbon dioxide. Purging is now widely practiced throughout the United States pickle industry to minimize bloater damage. While purging remains the best proven method for preventing bloater damage, it must be carried out continuously while cucumbers are in brine, making it a fairly expensive process.

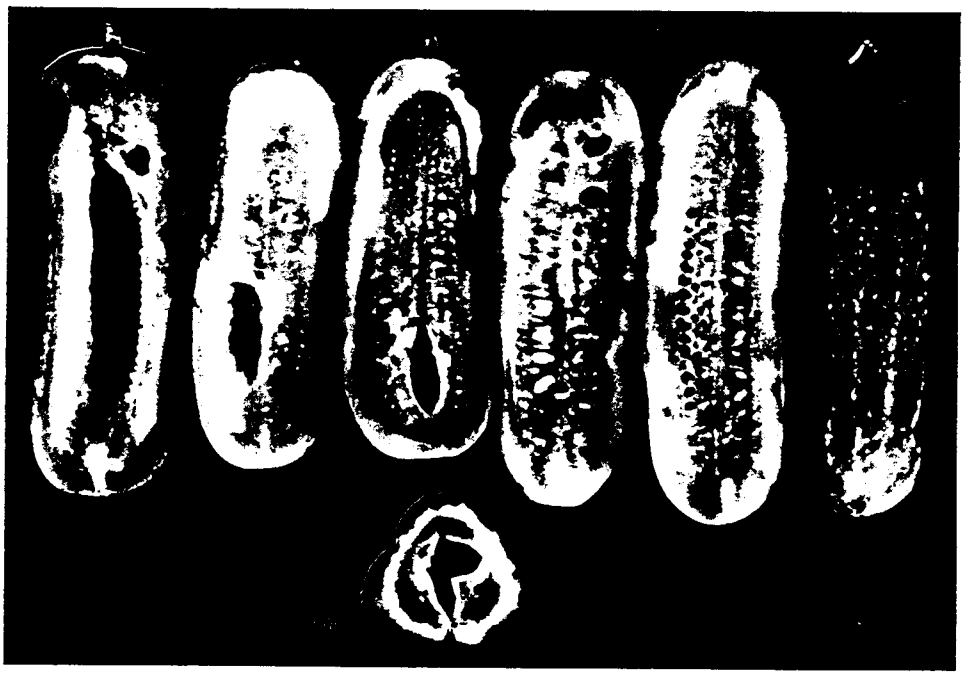
Mechanism of Bloater Formation

Horticultural and food scientists at NCSU have collaborated in recent experiments to determine the physical mechanism by which carbon dioxide gas causes bloating of brined cucumbers. It was hoped that the research would uncover more efficient ways to prevent the problem. These experiments involved measurements of the rate at which gases move through cucumbers as well as measurement of gas volumes and pressures within the fruit. Special devices had to be developed for these studies.

Cucumbers contain many microscopic pores on the surface known as stomates. These pores are connected to a vast complex of microscopic, gas-filled channels or intercellular spaces. This anatomy in the living fruit allows for rapid gas exchange with the atmosphere. Rapid exchange is necessary for respiration of the tissue in which oxygen is consumed from the atmosphere. When a fruit is in air, the major gas in these intercellular spaces is nitrogen which reflects the fact that these spaces exchange freely with the surrounding atmosphere which is also predominantly nitrogen gas.

During storage of fruit in brine, a portion of these spaces becomes filled with liquid. Other intercellular spaces remain filled with highly insoluble nitrogen gas. It is these isolated microscopic channels which become the nuclei for bloater formation.

As bacteria grow, carbon dioxide concentration in the brine increases. A large gradient develops for diffusion of carbon dioxide to the interior of the fruit. Because carbon dioxide is much more soluble than nitrogen, it can move into the fruit more rapidly than nitrogen gas can move out of the fruit. Movement of the carbon dioxide into the nitrogen-filled spaces ultimately results in sufficient gas pressure to cause the tissue to rupture or bloat. A hypothetical model



Gas exchange during brining causes hollow centers or "bloating" in cucumbers--a highly undesirable trait for a pickle. Although continuous purging with nitrogen during brining will reduce problem, NCSU scientists are experimenting with less costly one-time oxygen treatment.

was developed to explain the mechanism of bloater formation.

Gas Exchange Technology

A new experimental approach to preventing bloater damage involves intentional modification of the interior gases prior to brining. Brief exposure of raw fruit to an atmosphere of oxygen gas results in a rapid exchange of the internal atmosphere so that it contains only oxygen gas. When the oxygen-exchanged fruit are covered with brine, the internal oxygen is consumed by respiration and converted to carbon dioxide. The carbon dioxide dissolves in the fruit tissue, causing the development of a partial vacuum in the intercellular gas spaces. This vacuum causes brine to be drawn into the intercellular spaces until they become completely filled within a matter of a few hours. The gas-filled nuclei for bloater formation are thus eliminated. In fact, such fruit have been found to be highly resistant to carbon dioxide-induced bloater formation under laboratory conditons. Oxygen-exchanged cucumbers are readily distinguishable due to the desirable translucent appearance of the internal flesh, which is similar to fully cured, brine-stock pickles.

A problem associated with application of this technology is that bacteria normally present on the surface of cucumbers may be drawn into the interior of the fruit along with the brine. These undesirable bacteria may proliferate in the interior of the brined cucumbers. Washing or sanitizing the cucumbers may solve this problem. If so, the need for purging could be eliminated or reduced. Studies are underway to determine if gas-exchange technology can be rendered effective on a commercial scale.

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Not a giant's cave, but a pore in cucumber skin magnified by the scanning electron microscope. Linked to a network of intercellular spaces, such pores offer gases an easy access route.