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## Feedback Control of the Food Quality Trajectory Using In-Package Sensing and a Process-As-You-Go Approach

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Food preservation typically involves a single kill step followed by isolation of the product within a package, with passive hurdles or no further treatment: an open-loop approach to control food quality. An alternative vision is that of a closed-loop food control strategy, wherein the food is moderately processed as an initial stabilization (first kill-step) but the option for processing later as-needed is built into packages by implanting processing means within packages, and including sensors within the package, so that additional intervention steps are possible. We tested apple juice within electrode-embedded pouches with four main lines of samples. The first set (A) were moderately processed, cooled and held at 4°C for the storage period. The second set (B) was subjected to the same process but monitored for microbiological counts, sensory quality and impedance during 4°C storage, and processed either when sensory evaluation or microbiological counts suggested a need). The third set (C) was subjected to a mild conventional thermal pasteurization, and held without further processing, but evaluated for sensory quality, impedance and microbiological counts.

Raw samples fermented and spoiled quickly; pasteurized (C) samples showed decreasing counts during going below detectable limits within 2 weeks; the sample moderately processed once (A), showed microbiological recovery, and spoiled by 4 weeks; samples moderately reprocessed (B) had microbiota (mostly yeasts) that tended to recover after first processing, but were further reduced during reprocessing.

Sensory evaluation, scoring samples on visual and aroma attributes showed that the reprocessed samples (B) showed significantly superior scores on selected positive attributes; and maintained at least as good quality as the pasteurized samples (C) over storage. Reprocessing successfully staved off spoilage. In the later weeks, samples from the B and C groups also showed significantly superior attributes to commercial apple juice. We have also further investigated the potential for in-package sensing for food quality attributes. In particular, the variance in the rate of change of product impedance appeared to be a promising signature for impending spoilage. Reprocessing at this stage stabilized the impedance.