

## Diacetyl Substitutes In Bakery Product Manufacture

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**Rationale:** In 2008, a company using multiple butter flavorings in the manufacture of dry bakery mixes for commercial users replaced a liquid buttermilk flavoring containing 15-20% diacetyl (2,3-butanedione) with a proprietary substitute meant to lower occupational risk for diacetyl-related bronchiolitis obliterans. The flavoring supplier was directed to reformulate the buttermilk flavoring with no added diacetyl, diacetyl trimer, starter distillate, or increased acetoin concentration. Workers requested evaluation of buttermilk flavoring-related exposures and their respiratory health.

**Methods:** We evaluated volatile organic compounds emitted into the headspaces of 5 bulk buttermilk flavoring samples and measured ketones in air samples collected from workplace production areas during production of a cake doughnut mix containing the reformulated buttermilk flavoring. Workers were offered questionnaire interview and spirometry without and with bronchodilator. We calculated prevalence ratios (PR) for prevalences of symptoms, reported diagnoses, and spirometry abnormalities to expected prevalences from the third National Health and Nutrition Examination Survey, indirectly standardized for race, sex, age, and cigarette smoking status.

**Results:** Of five flavorings from five different flavorings manufacturers, 2,3-butanedione was present in 4; acetoin in 2; 2,3-pentanedione in 4; 2,3-hexanedione in 1; and 2,3-heptanedione in 3. Of Material Safety Data Sheets for 4 flavorings, only one listed a hazardous ingredient, which was acetoin. The predominant flavoring ingredient in the reformulated butter flavoring was 2,3-pentanedione; all other chemicals above were also present. 2,3-Pentanedione was the only ketone present at quantifiable levels in production area air samples, with concentrations up to 91 ppb in a personal air sample. Twenty-four (59%) workers participated in interviews, including 19 (70%) production workers and 8 of 11 who commonly handled flavorings. In their current jobs, two-thirds reported working with flour, half with powdered buttermilk flavorings, and one-third with liquid buttermilk flavorings. Use of buttermilk flavorings occurred weekly to monthly or longer, in contrast to daily use of flour. None of 23 workers who underwent spirometry had airways obstruction, but statistical excesses of spirometric restriction (n=4; PR 2.9), dyspnea hurrying on level ground or walking up a slight hill (n=10; PR 2.1), and ever having physician-diagnosed asthma (n=4; PR 3.6) existed in comparison to the U.S. population. No indices of exposure were associated with these health findings.

**Conclusion:** Without their or their employers' knowledge, workers who use flavorings may be exposed to substitute alpha-diketones from many manufacturers. Medical surveillance remains prudent for flavoring-exposed workers, despite regulatory efforts to prevent bronchiolitis obliterans by lowering diacetyl exposure.

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