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DIRECT NUMERICAL SIMULATION OF GASTRIC DIGESTION OF FOODS IN A STOMACH MODEL UNDER NORMAL AND REDUCED GRAVITY

Abstract

Human being has dreamed of habitation on Mars or other planetary bodies for a long history. One difficulty for habitation on Mars is the long journey from Earth to Mars. Traveling or habitation under reduced gravity for long periods may have deleterious effects on human health. One important problem experienced by humans is space adaptation syndrome (SAS), commonly referred to as space sickness. Deterioration of gastric digestion in a stomach is probably an important reason of SAS and the loss of body mass after long space journey. However, up to now, the influences of reduced gravity on gastric digestion in a stomach still have not received much attentions.

According to the vivo experiments, a gastric digestion process in a stomach has the characteristic velocity of about 0.03 m/s and the characteristic length of 0.1 m. The corresponding Reynolds number is about 3000, which leads to turbulent flows in the stomach. The role of turbulence in gastric digestion is still a mystery. Besides turbulence, gastric digestion is also combined with mass transfer, chemical reaction, and phase change, which make this process even more complicated.

In the current study, we investigated the gastric digestion of foods in a stomach with a direct numerical simulation (DNS) method, in which the possible turbulence is calculated directly without introducing any turbulence model. The effects of chemical reaction and multi-phase flows were neglected in the present study. Thus, the governing equations are the incompressible Navier-Stokes equations and the species transport equations. A finite volume method (FVM) was used in the direct numerical simulations. The solution is advanced in time with the second-order implicit backward method. A second-order central difference scheme is used for spatial discretization.

The gastric digestion processes under normal and reduced gravity were compared to each other according to our DNS results. The influence of reduced gravity on the turbulent flows and species transport in the stomach was investigated. Particular attention was paid to the discharging rate of food suspension from the stomach. The relationship between the emptying rate and the gravity was determined based on our DNS results.