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Numerical Study of Starch Concentration and Filling Initial Temperature on Cold Area changes in Canned Starch-based Food

A. Ranjbar Nedamani[1], A. M. Ziaiifar*[2], M. Parvini[3], M. Kashaninejad[4], Y. Maghsoudlou[4]

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Introduction: Canning is the most effective way to food preservation. Starch- based foods include the major food materials such as porridges. These foods due to sensitivity to high shear rates used in rotary retorts and thus texture decomposition, usually sterilized in static retorts. Broken heating behavior, can headspace and initial temperature have important role on heat transfer rate and the position of cold area in these products. Heat breaking phenomena in the thermal curve, which can be seen in foods containing starch, is essentially related to gelatinization and destroying of starchgelstructure. Starchmaybe naturally exist in foods ormay be added to food formulations as an additive to create the consistency, filler, volumeproviders, emulsionstabilizer and etc. However, during thermal processing of foodscontaining high amounts of starch, complexstructural changes occur which leads to viscosity increases. These changes aredue to structural changes of starch during gelatinization; such as irreversible swelling of the starch granules, melting of starchcrystals, leaking of starch granule compound. Depending on thetype of starch and its concentration, the final product can bean aqueous solution or agel structure. Increasing in starch viscosity after gelatinization leads to decrease in heating rate, but with the advancement of heating time, when most granule swelling occurs, and the granules are being disrupted and the viscosity is reduced. This leads to increase the heating rate. This dual behavior of starch dispersion viscosity, leads to break in heating curve. Such solutions are named broken heating curve foods.The aim of this study was numerical simulation of the effect of starch concentration and initial temperature on heat transfer rate of starch dispersion during static sterilization with COMSOL software.

Materials and methods: To prepare 100ml of 3.5 and 5% starch dispersion, 3.5 and 5 g starch was dissolved in 96.5 and 95 ml distilled water at 24.7°C, respectively. The solution was then heated at 50°C for 10 min to avoid sedimentation during the heat process. Samples were filled at 50 and 75°C initial temperatures. In each can (9.9×10.1cm), T- type thermocouple was placedin one-third length from the bottom. All measurements were performed in triplicates. The 8-port data logger (Pico-TC08, England) and related software (PicoLog) were used to record the temperature data with 10s intervals.The full filled cans (without headspace) were statically heated in vertical position with no rotation. Numerical solutions of the governing equations were performed by COMSOL Multiphasics 4.2b software. A BDF method for time stepping and Backward Euler to time discretization were used. The system used to run the test and solve the equation was Intel VR CoreTM i5CPU M 460 @ 1.70 GHz and 6GB RAM. Numerical simulation of COMSOL software include spairing two physical phenomena: heat transfer and fluidflow. Since the system was cylindrical shaped can contain food with natural convection, non-isothermal laminar flow equationswere used. For this problem, one geometry and two domains were defined. The governing equations for non-isothermal laminar flow for domains were defined. Since in thermal diffusion analysis, the formula methods are more correct than empirical methods, formula methods were used in this study for calculating j and f. The accuracy of these calculations was evaluated using CFD. Parameter - f is the slope of heating curve. $J_h$index, as a dimensionless correction factor.

Results and discussion: The results showed that thecold area is near theone-tenth ofcans bottom. Inboth product initial temperatures, varying the concentration of the starch in product from 3.5 to 5% leads to longer heating time. The increase in the thermal process time at one-tenth of can bottom is more than one-third of can bottom. The time which the dispersion reaches to static temperature also changes with starch concentration in

1, 2 and 4. PhD.student, Associate Professor and Professor, Department of food science, Gorgan University of Agricultural Sciences & Natural Resources.
3 Associate Professor- Faculty of Chemical Engineering, Gas and Petroleum, Semnan University, Semnan.
(*Corresponding author: ziaiifar@gmail.com)

dispersion. The temperature difference in 5% starch dispersion at static temperature at the end of heating process is more considerable than 3.5% starch dispersion. Higher starch concentration induces a decrease in *f* (The f_h coefficient represents thetime required to move heating process one cycle in heating curve and it can be calculated from the slope of the linear part of heat curve) at one-third of can bottom while an increase in f at one-tenth of can bottom. This behavior can be related to the fact that the starch gelatinization takes place earlier in one-third of can bottom than one- tenth due to the faster increase in temperature.

Keywords: Broken Heating Food, Sterilization, Cold Area, Heat Penetration, Initial Fill Temperature