Short Communication

Increased Amylase Digestibility of Pressure-treated Starch

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High pressure denatures proteins and kills microorganisms like high temperature (see reviews in refs. 1 and 2). Recently, we have proposed to use these phenomena for food processing and preservation. For further possibilities for use, we started to study the effects of pressure on starch, because there have been only a few reports concerning such effects in the past: Thevelein and Assche noted an upward shift of the gelatinization temperature of pressure-treated potato starch and Muhr et al. also observed changes in the gelatinization temperature of several starches after pressurization. Here we report that a pressure treatment enhances the susceptibility of starch to amylase action.

Analytical grade wheat, corn, and potato starches (Nacalai Tesque) were suspended in distilled water to obtain 5% (w/w) suspensions. The suspensions were put into small plastic bottles and compressed to 5000 kg/cm² by a pressure generator (Hikari Koatu Co., Type KP5B). n-Hexane was used as a pressure medium. The temperature of the sample was maintained at 25°C by immersing the pressure vessel in a water bath. After thus was kept for 20 min to 17 hr, the pressure was released, and pressure-treated starches were immediately used for amylase digestion as follows; 10~20 μg of α-amylase from Bacillus sp. (Sigma Chemicals, Type II-A) (liquefying type) was mixed with 0.4 ml of the starch suspension diluted by 0.1 M sodium acetate, pH 5.4, and incubated at 25°C for 30 min. Then, the 3,5-dinitrosalicylate (DNS) method was used to evaluate the digestion using maltose as the standard. Alkali-treated starch prepared as described by Takeda and Hizukuri was also digested under the same conditions. The extent of the digestion of pressure-treated starches was expressed as the digestibility relative to alkali-treated starches.

All starches tested were fairly resistant to amylase digestion after the pressure treatment at 25°C. However, the pressure treatment at an elevated temperature (45 or 50°C) increased the susceptibility of starches to amylase action, though such effects without pressure treatment were small or negligible (Fig. 1). Especially, the susceptibility of wheat starch was increased by the pressure treatment at 4000 kg/cm² and 40°C for 20 min. Among three starches, potato

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starch was the most resistant to pressure treatment; only 50% digestion was attained after the pressure treatment at 5000 kg/cm² and 25°C for 6 hr.

All curves of Fig. 1 have a peak. That is, curves of wheat and corn starches showed a steep rising, followed by a gradual falling. The curve of potato starch was also like this, as shown by a significant falling after the pressure treatment for 17 hr. These phenomena show that starches change their structure from a natural to a gelatinized structure and then to a new structure during long-term pressurization (see below). Although the gelatinized structure is attacked by the amylase used here, the new structure as well as the natural structure is resistant to amylase action.

In summary, the pressure treatment enhances the susceptibility of starches to amylase action. This is similar to the phenomenon that the pressure treatment of proteins increases the susceptibility to protease action. In analogy with protein denaturation caused by both pressure and heat, it may be said that starches are gelatinized by pressure as well as heat. The gelatinization is caused by a different pressure being appropriate for each starch, and is stimulated by increased temperature during the pressurization. Thus, the pressure treatment opens a way for amylase digestion of starches with a minimum use of heat. It is interesting to study the starch structure which is produced after prolonged pressurization and resists to amylase action, because it must be a unique construction formed in the environment of high pressure.

References