

ties of slip and adhesion during application than pure starch pastes. Potato and corn starches are more likely to be damaged during cooking, leading to yellowing (Rice, 1972). Rice starch has been found to be less stable than wheat starches on natural ageing (Clapp, 1978).

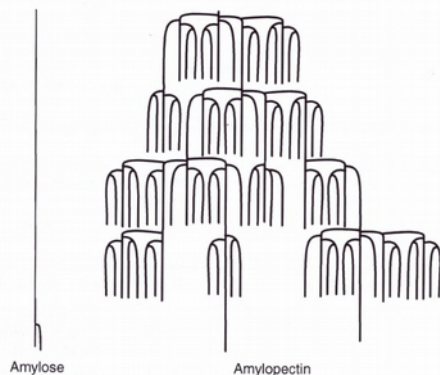


FIGURE 11.4 Indicative molecular structures of amylose and amylopectin.

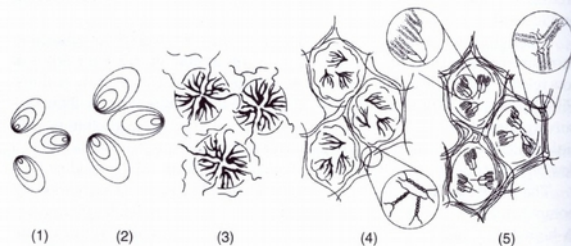


FIGURE 11.5 Changes in starch during the process of heating in water (cooking) and cooling (van der Borgh et al., 2005). (1) Dry native starch granules in their initial state. (2) Granules swelling in water at room temperature. (3) On heating to the gelatinization temperature, the granules absorb water and are disrupted, the starch molecules swell losing their helical structure and crystallinity, amylose molecules dissolve and disperse in the surrounding liquid, depending on the extent of heating and agitation, the amylopectin molecules swell but retain some of the shape of the original granules. (4) On cooling, the amylose molecules reform helical chains causing the liquid to gel. (5) On storage, the amylose helical regions expand and the amylopectin molecules reform helical regions (retrogression), becoming increasingly stiff and insoluble in water. Image courtesy of Jan Delcour.

TABLE 11.2 Properties of Some Starches

Plant Type	Amylose Proportion in Starch (%)	Degree of Polymerization, DP_n		Gel Formation
		Amylose	Amylopectin	
Wheat	~25	1300	7500	Strong
Rice	16–19	1100	10,000	Little
Potato	23	4900	11,200	Little
Rye	26			
Corn	22–28	930	16,000	Strong
Tapioca	17–22	2600		Little

Sources: Takeda et al. (2003), Vandeputte and Delcour (2004).

Furunori is a modified wheat starch made in Japan by ageing starch paste under water for years. The molecular weight of the starch is reduced considerably by microbial action and the amylose is almost totally retrograded (Daniels, 1988; Hayakawa et al., 2002). It has less tack and greater gel stiffness.

Starch is modified by hydrolysis and oxidation at elevated temperatures to produce easily soluble British gums and dextrans that have very low molecular weights and that have been widely used as remoistenable adhesives on paper tapes and labels. The molecular weight of starch can be modified more subtly by controlled hydrolysis of the molecules while still in the granules (Van Steene and Masschelein-Kleiner, 1980). When acid-catalysed hydrolysis is carried out below the gelatinization temperature, the starch molecules are attacked in the amorphous regions of the granule. This increases the proportion of unbranched but shorter polymer chains, resulting in a lower solution viscosity and an increased tendency to gelation (Taggart, 2004).

Starch is traditionally identified by the intense blue colour produced when amylose is reacted with an iodide solution. The iodide forms a complex with a surrounding amylose single helix, which amylopectin cannot form. This reaction works only with soluble amylose so retrograded amylose will react weakly, if at all.

Conservation

Flour pastes are traditional adhesives for paper and for use in book bindings, though starch pastes are now preferred. Typical proportions are (BS 4971:1, 1973):

- wheat starch, 400 g;
- water, 1150 ml.