Action of Bacterial α-Amylase on Gelatinization Characteristics of Waxy-Rice Flour

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ABSTRACT

Under conditions of the Brabender Viscograph, bacterial α-amylase was more effective in its liquefying action on pastes of waxy-rice flour than on those of normal rice starch. Digestion of waxy-rice flour at 36°C. for 100 min. without enzyme decreased gelatinization time but increased maximum viscosity. This digestion was without important effects on the action of the amylase at 0.4 and 2.0 SKB units. Digestion of the flour at 57°C. for 30 min. without enzyme increased gelatinization time and decreased viscosity. With enzyme at 0.4 SKB unit, this digestion gave lower paste viscosity than other treatments at the same enzyme level.

Waxy-rice starch is of interest to the food industry because of its outstanding freeze-thaw and low-temperature stability. In this respect it differs from waxy-maize and waxy-sorghum starches, which must be esterified to achieve such stability. Its freedom from retrogradation or setback is advantageous in some other applications such as those of the textile and paper industries. Halick and Kelly (1) found that waxy rice has low gelatinization temperature and viscosity, which they attributed to the low molecular weight of its amylopectin. In contrast, they found that amylopectin of common rice starch has relatively high molecular weight.

This study was undertaken to investigate the effects of bacterial α-amylase and heat treatment on the pastes of waxy-rice flour.

MATERIALS AND METHODS

The waxy-rice sample, variety IR 253-4-1-2-1, was supplied by T. T. Chang of the International Rice Research Institute, Manila, Philippines, who stated it was free from amylose. It was ground in a Homoloid mill, then sifted through a 40-mesh Tyler screen. Protein was 9.0% (1.53 N × 5.9), dry basis; and moisture, 11.7%. Commercial normal rice starch of 0.9% protein (0.15 N × 5.9), dry basis, and 10.8% moisture was used for comparison. Dried and purified α-amylase was produced from *Bacillus subtilis* S-3217 (2).

Moisture and total nitrogen were determined by AOAC procedures (3).

Viscosity was determined in the Brabender Viscograph (Brabender Corporation, Rochelle Park, N.J.). Waxy-rice flour was used at 8.09% concentration; normal rice starch, at 10.2% (dry basis). All tests were begun at 30°C. immediately after the suspensions were prepared. The data obtained are based on two repetitions of experiments. Rice starch was treated with 0.4, 2.0, 8.0, and 12.0 SKB units of bacterial α-amylase and heated to 95°C. at 1.5° per min. Waxy-rice flour was treated with 0.4 and 2.0 SKB units of bacterial α-amylase. Three heat treatments were used: a) Heated at 1.5° per min.; b) held at 36°C. for 100 min., then heated at 1.5° per min.; c) held at 57°C. for 30 min., then heated at 1.5° per min. All were held at 95°C. for 16 min., then cooled to 50°C. and held for 15 min.

RESULTS AND DISCUSSION

Gelatinization and pasting properties of the samples heated to 95°C. without a digestion period are shown in Table I. Gelatinization temperature was taken as the point at which the curve began to rise, and gelatinization time as the time from initial rise of the curve to the maximum viscosity. Setback is the change in viscosity from the initial value at 50°C. to the maximum value.

Without enzyme, waxy-rice flour gelatinized at lower temperatures and reached the maximum more quickly and at a lower temperature than did normal rice starch. Its viscosity decreased sharply from the maximum, 480 Brabender units (B.U.) at 72°C. to 325 B.U. at 95°C. The viscosity of rice starch decreased only slightly from its maximum of 610 B.U. at 94.5°C. to 600 B.U. at 95°C. This is due to the weaker internal organization of the waxy-rice flour, which swells freely at relatively lower temperatures, whereas the normal rice starch is strongly bonded internally. Waxy-rice flour decreased in viscosity when cooled to 50°C., in contrast to the normal rice starch, which increased markedly. These observations are in agreement with those of Halick and Kelly (1). Whereas the viscosity of waxy-rice flour increased continuously to the maximum, normal rice starch gave two regions of rapid viscosity increase before the maximum was reached. One was at 82°C.; the other, from 90° to 94.5°C. This is indicative of two sets of bonding forces within the granules (4).

Bacterial α-amylase had a greater liquefying effect on waxy-rice flour than on normal rice starch. For example, 2 SKB units reduced the maximum viscosity of waxy-rice flour from 480 to 100 B.U., whereas the decrease for normal rice starch was from 610 to 360 B.U. Eight SKB units of the amylase were required to produce the same effect on the viscosity of normal rice starch at the maximum, at 95°C., and at 50°C., that 2 SKB units gave with the waxy-rice flour.

In the investigation of the effects of digestion on the action of bacterial α-amylase on waxy-rice flour, many experiments were conducted to find the optimum temperature and holding time for the highest maximum viscosity without enzyme. This was found to be 36°C. for 100 min. These conditions and 57°C. for 30 min. were selected for study. Results are given in Table II.

Digestion at 36°C. for 100 min. without enzyme decreased gelatinization time (4 min. to 3 min.), lowered temperature at maximum viscosity slightly, and increased maximum viscosity from 480 to 540 B.U. Comparison of viscosities (at the maximum, at 95°, and at 50°C.) of waxy-rice flour treated with 0.4 and 2.0 SKB units of the amylase with corresponding values for the same enzyme treatment but no digestion (Table I) shows that digestion had no appreciable effect on these values.

Treating waxy-rice flour with bacterial α-amylase had little effect on gelatinization temperature or on temperature at maximum viscosity (Tables I and II). In contrast, the enzyme at all levels lowered the gelatinization temperature of normal rice starch and at higher levels also lowered the temperature of maximum viscosity (Table I, data for normal rice starch). Similar results were obtained by Anker and Geddes (5), who stated that diastating common starches decreased both the temperature of transition and that at peak viscosity.

When aqueous starch suspensions are held at elevated temperatures under conditions which prevent gelatinization, this heat-moisture treatment raises the gelatinization temperature and decreases swelling power and viscosity of some

TABLE I. EFFECT OF BACTERIAL α-AMYLASE ON AMYLOGRAPH CHARACTERISTICS

Enzyme Concentration SKB Units	Gelatinization Temperature °C.	Temperature at Maximum Viscosity °C.	Gelatinization Time min.	Maximum Viscosity B.U.	Viscosity at 95°C. Initial B.U.	Viscosity at 95°C. After 16 min. B.U.	Viscosity at 50°C. Initial B.U.	Viscosity at 50°C. After 15 min. B.U.	Setback B.U.
				Waxy-Rice Flour					
0	66.5	72	4	480	325	300	400	400	−80
0.4	66.5	71	3.5	300	190	180	260	280	−40
2	67.5	72	3	100	40	40	75	60	−25
				Commercial Normal Rice Starch					
0	79	94.5	11.5	610	600	540	980	900	+370
0.4	78.5	94.5	10	555	540	460	918	840	+363
2	75	94.5	15	360	360	285	560	530	+200
8	69	86	11.5	170	40	25	90	90	−80
12	68	82	9.5	150	25	10	40	40	−110

TABLE II. EFFECT OF BACTERIAL α-AMYLASE ON AMYLOGRAPH CHARACTERISTICS OF WAXY-RICE FLOUR

Enzyme Concentration SKB Units	Gelatinization Temperature °C.	Temperature at Maximum Viscosity °C.	Gelatinization Time min.	Maximum Viscosity B.U.	Viscosity at 95°C. Initial B.U.	Viscosity at 95°C. After 16 min. B.U.	Viscosity at 50°C. Initial B.U.	Viscosity at 50°C. After 15 min. B.U.	Setback B.U.
				Digested at 36°C. for 100 min.					
0	66.5	71	3	540	395	360	460	460	−80
0.4	67.5	72	3	280	205	195	270	270	−10
2	69	74	3	100	60	60	100	100	0
				Digested at 57°C. for 30 min.					
0	67	73.5	4	320	280	260	350	350	−30
0.4	67	72	3	160	140	140	205	205	+45

starches (4,6). This may account for the increase in gelatinization time and decrease in viscosity of waxy-rice flour when it was held at 57°C. for 30 min. without enzymes (Table II). With bacterial α-amylase at 0.4 SKB unit this heat treatment gave a paste lower throughout the viscosity curve than the other treatments at the same enzyme level.

These observations suggest the possibility that in applications where enzyme-treated rice starch is used, waxy-rice flour treated with bacterial α-amylase may be advantageous.

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