PHYSICO-CHEMICAL INVESTIGATIONS ON VARIETAL DIFFERENCES IN RICE.

III. Electrical Conductivities of Rice Suspensions in Water.

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Introduction.

IT has been established by Coehn, Grüzewska, Samec and others[1] that sols or suspensions of starch in water carry a negative charge. This charge has been attributed to amylopectin. Amylose has been found to be electrically neutral. Samec[1] has also noticed that the specific conductivity of a starch suspension increases on heating in an autoclave at 120° C. At the same time, the migration velocity in an electric field diminishes. There is a decrease in viscosity as well. He attributes these changes, which take place on continued heating, to the liberation of the electrolyte initially attached to the starch micelles. This work of Samec on the starches indicated the possibility of correlating quality of rice with conductivities of suspensions of rice in water. Conductivity measurements of such suspensions were therefore undertaken in this laboratory.

Experimental.

Four varieties of rice (Mysore Kaddi, Coimbatore Sanna, Doddabyra and Doddabele, all harvested in 1933) were employed in the experiments. A powdered sample from each, passing completely through a 100-mesh sieve, was prepared in the manner indicated in a previous paper (Part II). The measurements of conductivity were made in the usual manner with a circular type of wheatstone bridge and a telephone receiver. Conductivity water (sp. condy $= 1 \times 10^{-6}$ r. ohm at 30° C.) was employed in preparing the suspensions. Measurements of specific conductivity were made, at definite intervals of time, at four different temperatures 0° C., 30° C., 58° C. and 96° C. By adding thymol or toluene, the suspensions were protected from attack by micro-organisms.

Measurements were made at 0° C. by keeping the cell in a vacuum jar containing powdered ice in equilibrium with distilled water. The conductivity was very small to start with but slowly increased with time and did not become constant even after a week.

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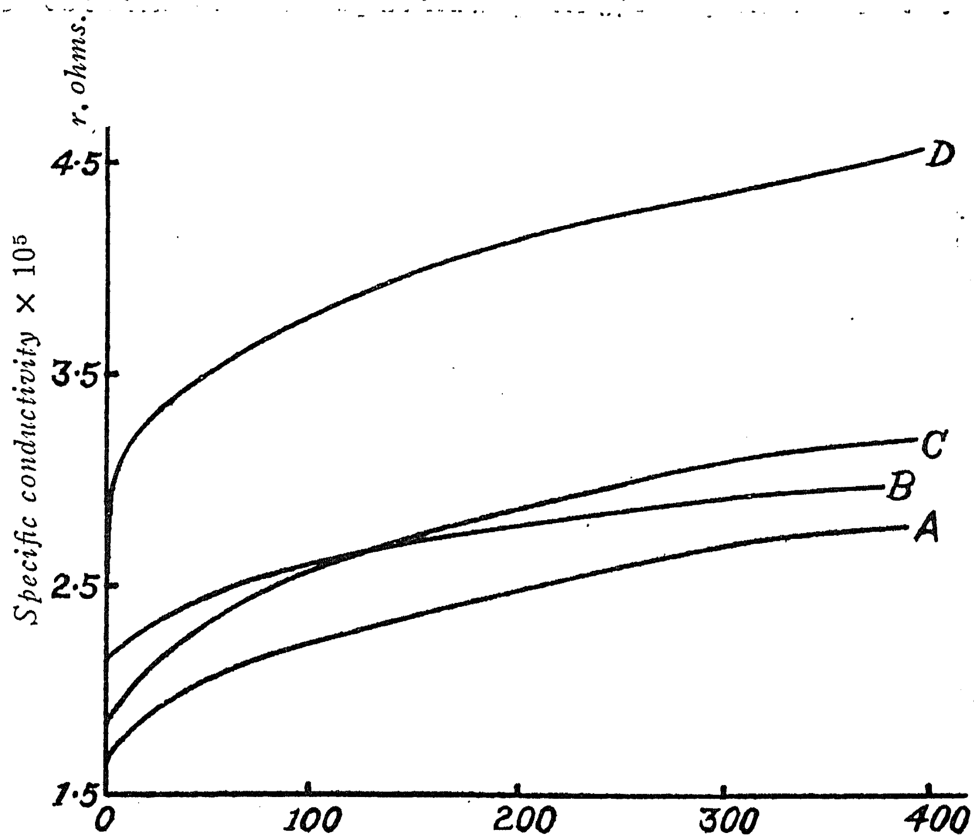
[1] M. Samec, *Trans. Far. Soc.*, 1935, **31**, 395 ; J. Alexander's *Colloid Chemistry*, **4**, 167.

An air-thermostat was employed for measurements at 30° C. The initial and the final conductivities, and the rate of increase of conductivity with time, were all higher than at 0° C. The increase was rapid at first and appreciably slowed down after about 10 hours. A fairly constant value was obtained after four days.

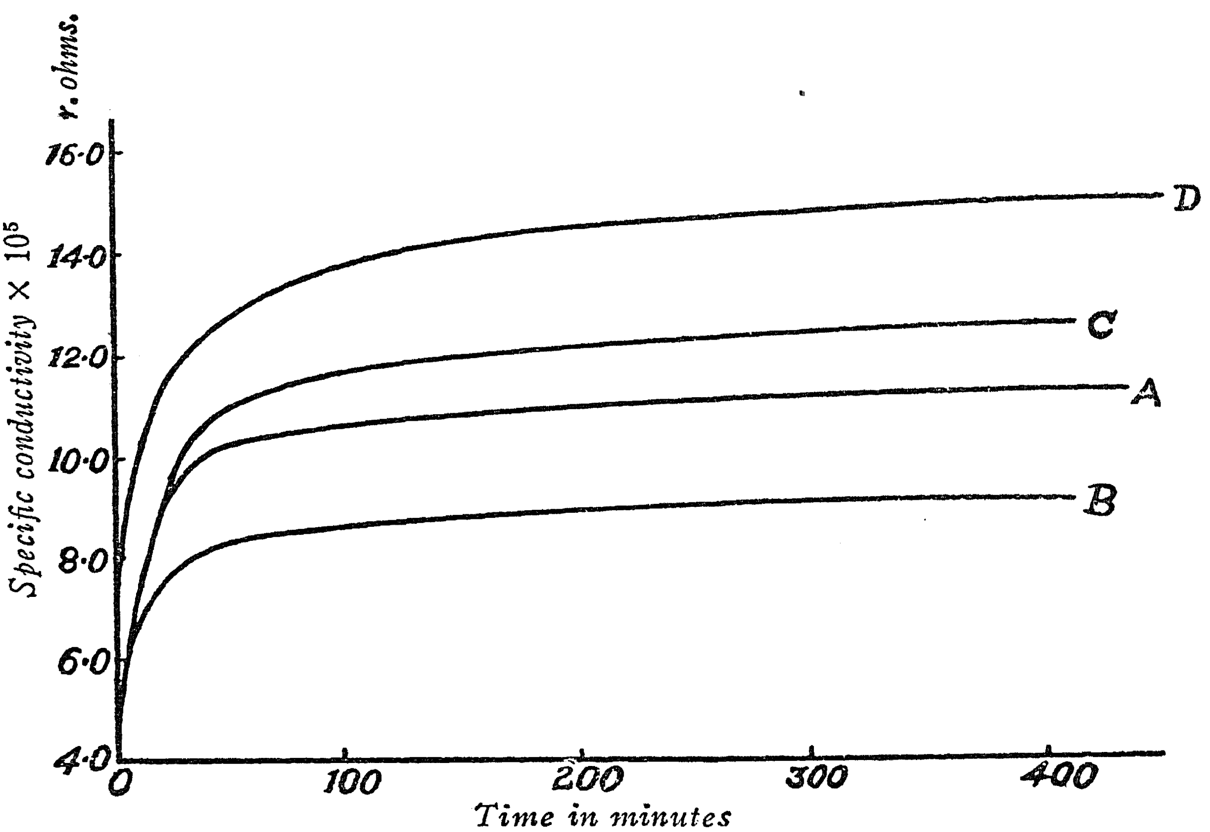
Effect of higher temperatures on the conductivity was studied by maintaining the suspensions at 58° C. or 96° C. in a water-bath. The actual conductivity determination however, was carried out at 30° C. (after cooling the hot suspension). The increase in conductivity with time was found to be high. At 58° C. constancy was attained in two days and at 96° C., in less than two hours. In the latter case however, a very small increase persisted even after heating for twenty-four hours. In all the experiments, the results were found to be reproducible. The results obtained are shown in Table A and Figs. 1–3.

Whole grains, in place of powders, were also used in the experiments at 58° C. and 96° C. The conductivity increase was very slow at 58° C. and constancy was not attained even after four days. But at 96° C., two days were found to be sufficient. Reproducibility of results however, was not



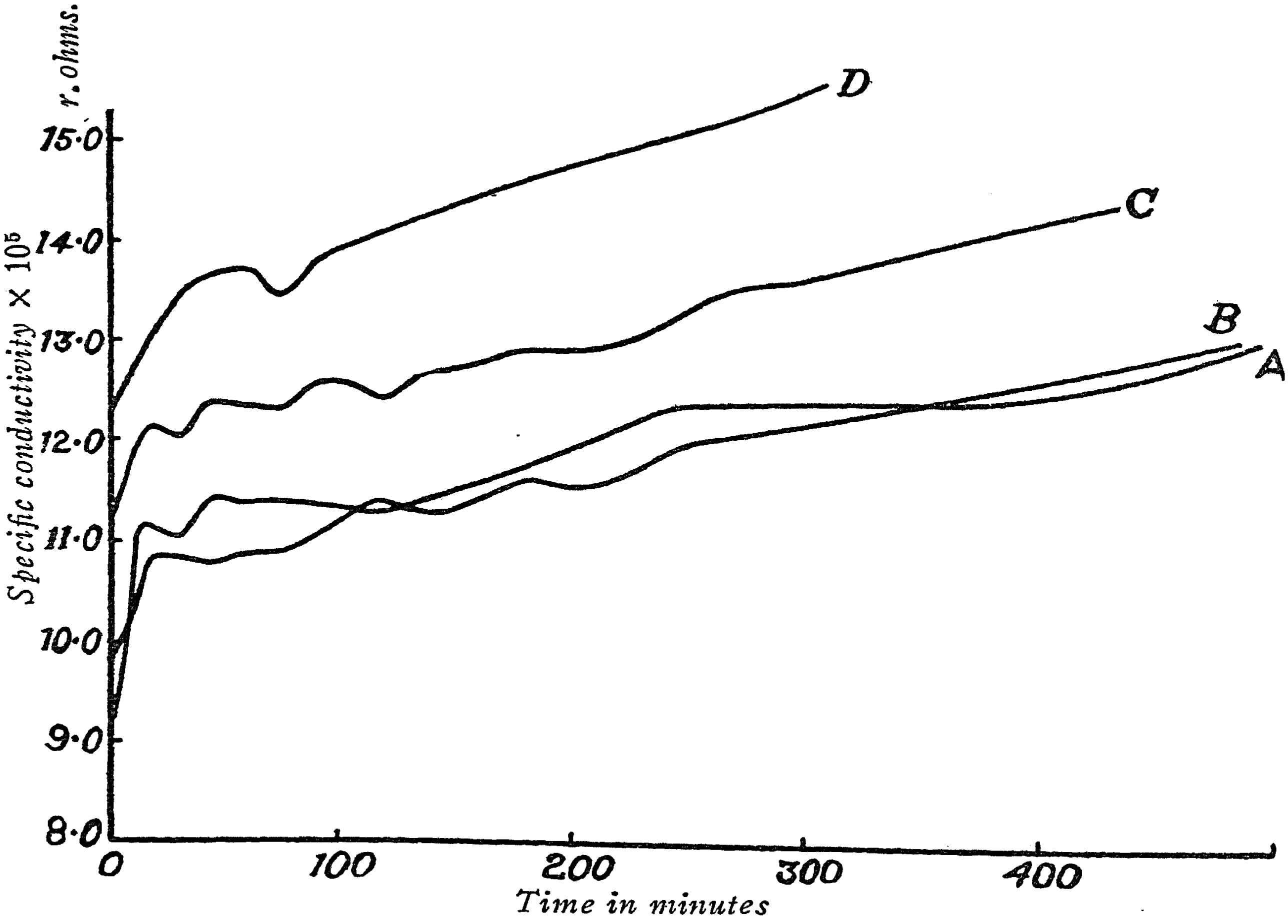
A = Doddabyra. *B* = Mysore Kaddi. *C* = Coimbatore Sanna. *D* = Doddabele.

FIG. 1. Conductivity of 1% rice-powder suspensions in water at 0° C.



A = Doddabyra. *B* = Mysore Kaddi. *C* = Coimbatore Sanna. *D* = Doddabale.

FIG. 2. Conductivity of 1% rice-powder suspensions in water at 30° C.



A = Doddabyra. *B* = Mysore Kaddi. *C* = Coimbatore Sanna. *D* = Doddabele.

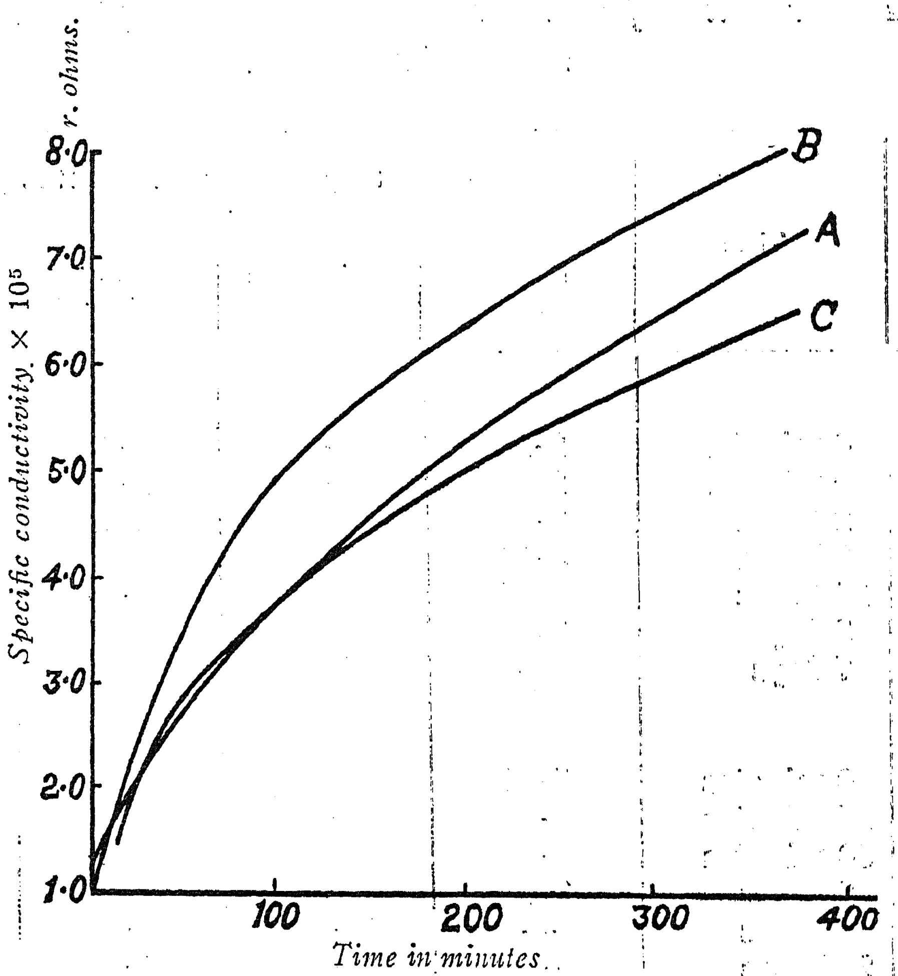
FIG. 3. Conductivity of rice-powder suspensions in water at 58° C.

TABLE A.

Time variation of conductivities of 1 per cent. suspensions of rice powder in water.

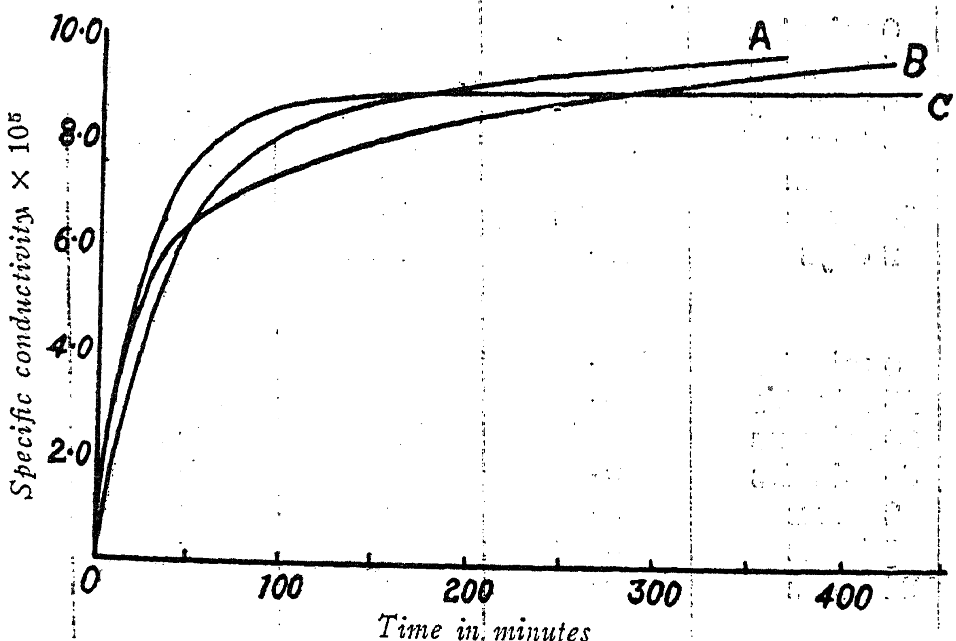
Temp.	Time	Conductivity observed (in r. ohms × 10^5)			
		Mysore Kaddi	Coimbatore Sanna	Doddabyra	Doddabele
0° C.	0 minutes	2·12	1·83	1·64	2·59
	30 minutes	2·35	2·23	2·00	3·36
	2 hours	2·65	2·64	2·30	3·90
	8 hours	3·14	3·40	2·94	—
	24 hours	4·25	4·55	4·29	4·82
	3 days	5·42	—	5·68	6·72
	7 days	—	6·97	6·68	7·75
30° C.	0 minutes	5·04	4·76	3·98	5·98
	15 minutes	7·42	8·34	8·44	10·56
	30 minutes	8·18	10·20	9·71	12·22
	2 hours	8·70	11·75	10·75	14·00
	8 hours	—	12·70	11·32	15·15
	24 hours	9·84	13·79	11·98	17·99
	2 days	9·99	14·96	13·91	—
58° C.	0 minutes	11·27	9·75	9·14	12·30
	15 minutes	12·12	10·78	11·17	12·91
	60 minutes	12·31	10·91	11·35	13·72
	2 hours	12·42	11·45	11·40	14·00
	8 hours	14·36	12·96	12·89	14·78
	24 hours	17·22	15·81	15·58	20·54
	2 days	17·44	17·91	16·86	24·84
96° C.	0 minutes	9·46	12·3	11·2	13·7
	15 minutes	9·39	11·7	11·2	14·0
	30 minutes	9·58	11·8	11·2	14·1
	60 minutes	9·46	11·8	11·2	14·2
	2 hours	9·46	11·6	11·1	14·1
	8 hours	9·62	11·8	11·5	14·2
	24 hours	9·74	11·9	11·3	14·3

as high as with powdered rice. The results are shown in Table B and Figs. 4 and 5.



A = Doddabyra. *B* = Mysore Kaddi. *C* = Coimbatore Sanna.

FIG. 4. Conductivity of 1% rice grain suspensions in water at 58°C.



A = Doddabyra. *B* = Mysore Kaddi. *C* = Coimbatore Sanna.

FIG. 5. Conductivity of 1% rice grain suspensions in water at 96°C.

TABLE B.

Time variation of conductivities of 1 per cent. suspensions of rice grains in water.

Temp.	Time	Conductivity observed (in r. ohms × 10^5)			
		Mysore Kaddi	Coimbatore Sanna	Doddabyra	Doddabele
58° C.	0 minutes	0·99	0·87	1·14	0·96
	30 minutes	2·70	2·02	2·15	2·19
	60 minutes	3·75	2·93	2·87	2·83
	2 hours	5·27	4·03	4·04	4·04
	4 hours	6·87	5·38	5·70	5·70
	8 hours	8·30	6·98	7·85	7·55
	24 hours	10·54	8·82	10·10	9·78
	2 days	11·78	10·15	11·73	11·04
96° C.	0 minutes	1·79	1·47	1·15	1·27
	30 minutes	5·99	5·67	4·97	4·23
	60 minutes	8·17	6·86	7·24	6·95
	2 hours	8·85	7·88	9·10	9·28
	4 hours	9·25	8·96	9·36	10·22
	8 hours	9·62	10·24	10·26	11·18
	24 hours	9·84	10·86	11·24	11·77
	2 days	10·10	11·63	..	11·97

Discussion.

The results show that, in general, there is an increase in conductivity as the time of contact of the rice or rice powder with water increases. The increase is due to the liberation of electrolytes. There can be no appreciable liberation of electrolyte caused by hydrolysis of amylopectin, for the work of Samec has shown that such hydrolysis is slow even at 120° C. in an autoclave. (The initial conductivity of a 2 per cent. suspension of pure potato starch was found by Samec to be about 2×10^{-5} r. ohms, and increased to about 8×10^{-5} r. ohms after it had been hydrolysed at 120° C. for 6–8 hours.) The curves however, show that the inferior varieties show a slightly higher specific conductivity than the superior ones, but the differences are not very significant.

The electrolytes responsible for the conductivity increase must therefore have been present in the rice in the free state, and were brought into solution as the water moved into the capillary spaces of rice. It is significant that while at 30° C. about four days were required for attainment of maximum conductivity, the corresponding time at 58° C. was two days and at 96° C. it was about half an hour. There is no doubt that at 96° C., owing to rapid hydration, the capillaries were quickly disintegrated and the electrolyte easily brought into solution.

The conductivity curve for 58° C. shows that there is a rapid initial increase, then a region of fluctuation and finally a slow increase in conductivity. The fluctuations seem to be due to the increase in viscosity, which tends to reduce the specific conductivity. The final conductivity of the suspension subjected to heat treatment at 96° C., was much less than the value for other temperatures owing to the fact that the suspension heated at 96° C. was markedly viscous on cooling to 30° C.—the temperature at which conductivities were measured.

Summmary.

The increase in conductivity with time of rice and rice powder suspensions in water has been studied at different temperatures. Varietal differences in the rates of increase have been observed, but they are not characteristic of quality. The increase in conductivity cannot be attributed to electrolytes liberated by hydrolysis of amylopectin as such hydrolysis is inappreciable, but is to be accounted for, by the dissolution of electrolytes already present in the free state in rice.