

# Net Density of Starch

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(Received May 2, 1935)

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## Abstract

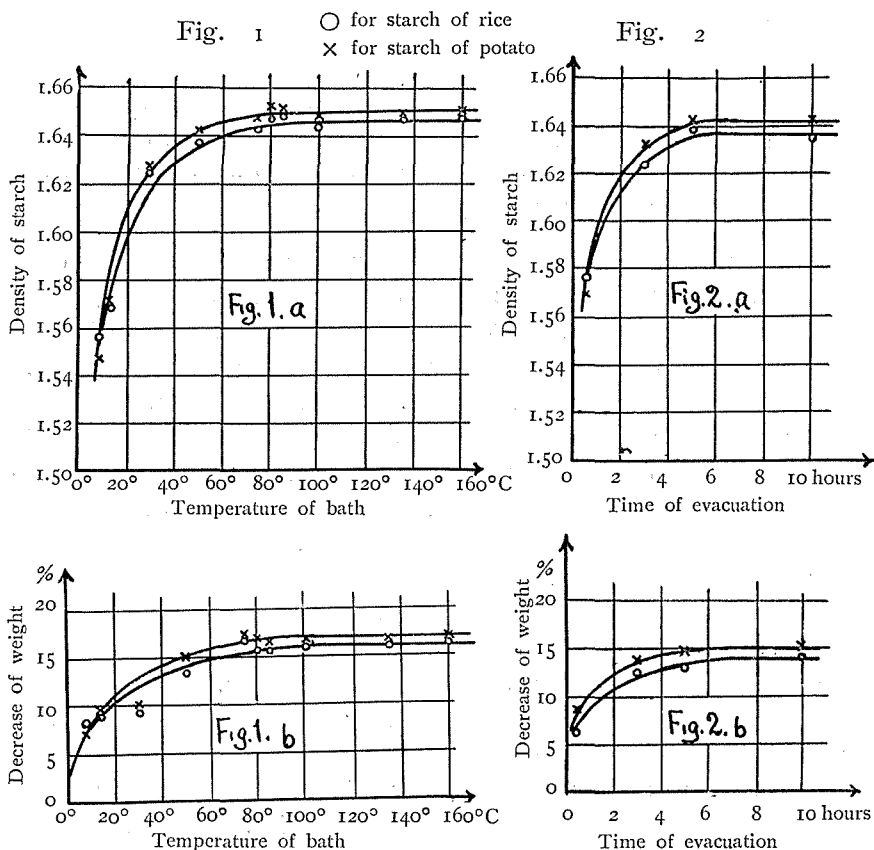
The net densities of starches are observed by applying the method of measuring densities by perfect evacuation. The density of purified starch of rice is found by measurement to be 1.646 and that of purified starch of potato 1.650. These are the greatest values hitherto observed.

In experiments recorded in a paper<sup>1</sup> previously published, U. Yoshida and the present writer measured the net density of ramie-cellulose by the method of perfect evacuation, and noted that the method can be well applied to any substances, powdery, fibrous or porous, which are liable to occlude gases and water. When the writer examined the starches of rice and potato by means of X-rays<sup>2</sup>, the more reliable values of the densities of starches are required, as the differences between the lattice-forms of the starches of rice and potato seem to be fundamental even in the perfectly dry state. In this instance the writer applied the method of perfect evacuation in measuring the net densities of starches in the same way as in the case of ramie-cellulose. Experimental details must be referred to the above-mentioned paper<sup>3</sup>, while some results and discussions are shown below.

In preliminary experiments, the writer measured the densities of purified starches of rice and potato evacuated for various durations of time by heating at different temperatures in the bath of water or oil. The results of the experiments are shown in Figs. 1 and 2. In the case of Fig. 1 the time of evacuation was kept constant at 5 hours, and the temperature of the bath was varied between 10°C and 160°C. This temperature of the bath being taken as abscissa, the densities of purified starches of rice and potato are represented as ordinate in Fig. 1a; and the reduction of weight of the specimen by evacuation, which is represented as a percentage of the original weight of the unevacuated specimen dried in an ordinary "Adsol" dessicator, is taken as ordinate in Fig. 1b. In the case of Fig. 2 the temperature

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1. U. Yoshida and B. Takei, *These Memoirs*, **15**, 1 (1932)
  2. B. Takei: *Jap. Jour. Phys.*, **8**, 85 (1933)
  3. U. Yoshida and B. Takei: *Loc. cit.*

of the heating bath was kept constant at  $50^{\circ}\text{C}$ , and the time of evacuation was changed from 30 minutes to 10 hours. The time of evacuation is taken as abscissa in this case, and the ordinates in Figs. 2a and 2b have the same meanings respectively as in Fig. 1. From



the curves thus represented in Figs. 1 and 2, we may conclude that the most suitable temperature of heating is between  $70^{\circ}\text{C}$  and  $90^{\circ}\text{C}$ , and that the convenient time of evacuation with the Cenco Hyvac pump is about 5 hours, for the densities and the reduction of weight remain unchanged at higher temperatures than  $90^{\circ}\text{C}$  and for longer times of evacuation than 5 hours. It must be noted that when starches are heated to a temperature higher than about  $100^{\circ}\text{C}$  slight carbonization begins to take place and the specimen becomes yellowish.

By taking the various precautions before stated, the measurements of the most reliable densities of purified starches of rice and potato are

obtained. These are tabulated in Table I. The quantity of the specimen used in this case was from 2 gms. to 5 gms; and the probable error of the measurements was about  $\pm 0.2$  percent. The mean density of the purified starch of rice is 1.646 and that of the purified starch of potato is little greater, viz. 1.650. As the density of rice starch was in every experiment observed to be a little smaller than that of the potato starch, this small difference of the densities of the two kinds of starches does not appear to be due to mere experimental errors.

Table I. Net Densities of Starches and their Decrease of Weight by Evacuation

Evacuation		Net densities		Decrease of weight in %	
Temperature	Time	Rice starch	Potato starch	Rice starch	Potato starch
75°C	5 hours	1.642	1.647	16.72	16.76
80°C	5 hours	1.647	1.653	15.55	16.73
85°C	5 hours	1.648	1.651	15.49	16.55
Mean values		1.646	1.650	15.92	16.55

So far as the writer is aware, the values of the densities of purified starches obtained by him are the highest observed hitherto for starches. For example, in the standard tables of physical and chemical constants the density of starch is tabulated as 1.50<sup>1</sup> and 1.56<sup>2</sup>. The reason why the writer's values are larger than those tabulated in the ordinary tables will be easily understood from the fact that the weights of the starches contained in the "Adsol" dessicator decreased by perfect evacuation, by about 16 percent of the original weight in the dessicator, as shown in the last column of Table I.

As will be seen in Figs. 1 and 2, the weight of the specimen decreases with evacuation in parallel with the increase in its density. This seems to be mainly due to the expulsion of water occluded in the specimen, for the colour of the electric discharge through the Geissler tube, connected in parallel with the glass tube containing the specimen, is the same as that peculiar to hydrogen gas. Thus assuming that the reduction in weight by evacuation is entirely due to the extraction of liquid water adhering to the specimen, the writer calculated the densities of the unevacuated specimens from the experimental data of Table I. These calculated values correspond fairly

1. International Critical Tables 2. Smithsonian Physical Tables

satisfactorily with the values obtained by evacuating the specimens for about 40 minutes by cooling them in a freezing mixture so as to prevent the extraction of liquid water from the specimen as far as possible. This will be seen clearly by comparing the data tabulated in Table II. Such coincidence between the calculated and the measured values seems to justify the previous assumption that the reduction in weight of the specimen is mainly due to the expulsion of liquid water adhering to the specimen.

Table II. Calculated Densities of the Unevacuated Starches and the Densities measured by using Freezing Mixture

	Rice starch	Potato starch
Mean densities by perfect evacuation	1.646	1.650
Reduction in weight by perfect evacuation	15.92 %	16.55 %
Densities of unevacuated starch calculated from the above data	1.493	1.476
Densities measured by using freezing mixture	1.499	1.493

Here it must be remarked that the present experiment was performed on the assumption that the net density of starch does not suffer any appreciable change by its swelling in water. If there is any doubt on this point, it will be safer to measure the density of starch again by dipping it into some suitable liquid other than water. It would be interesting to measure the density of soluble starch or granulose by the method of perfect evacuation by immersing it in alcohol.

In conclusion, the writer wishes to express his sincere thanks to Prof. U. Yoshida for his kind guidance during the research. His hearty thanks are also due to Prof. K. Kondo of the Department of Agricultural Chemistry for furnishing all the test materials.