

Equilibrium moisture content for sorption of water vapor by milled rice

J.P. Pandey, Department of Post Harvest Process and Food Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar 263145, Udham Singh Nagar, India

Hygroscopicity is a fundamental characteristic of biological materials that influences virtually every aspect of handling, storage, manufacturing, and consumption of food products. When such materials are exposed to the atmosphere, they tend to lose or gain moisture, depending on temperature and relative humidity. The process by which hygroscopic materials lose or gain moisture is called sorption, and the moisture content at equilibrium is known as equilibrium moisture content (EMC).

EMC data are directly applicable to the analysis of mass transfer phenomena in storage and drying processes. Milled rice, like other grains, is hygroscopic in nature—it loses or gains moisture when the vapor pressure of water surrounding the grain is different from that inside the grain. Basic EMC data on milled rice with different milling degrees in relation to temperature and relative humidity of the storage atmosphere are necessary for analyzing the moisture exchange process during storage. This study was undertaken to establish the EMC of rice with different milling degrees under relative humidities ranging from 0.1 to 0.9 and temperatures of 20, 30, and 40 °C.

The experiments were conducted using a recently released hybrid rice variety (Pant Sankar Dhan-1). Sorption characteristics of milled rice with different degrees of milling (0%, 3.8%, 6.6%, 10.3%) were studied at prespecified temperatures and relative humidity under adsorption and desorption using the static method. In the static method, the material was placed in a desiccator containing a saturated salt solution or sulfuric acid solution that gives a certain specific relative humidity. The grain was allowed to equilibrate in still, moist air. Aqueous sulfuric acid and hydrochloric acid solutions of various concentrations was used to control the relative humidity of moist air between 0% and

100%. The vapor pressure above an acid solution depends on the chemical, concentration, and temperature.

The EMC values for milled rice of 3.8%, 6.6%, and 10.3% degree of polish ranged from 6.9% to 24.2% (adsorption) and 7.6% to 26.2% (desorption); 6.6% to 26.2%, and 8.0% to 27.0%; and 6.0% to 24.0% and 8.0% to 25.0%, respectively. For 0% milled rice (brown rice), the minimum and maximum EMC values during adsorption were 7.0% and 24.2%, and those for desorption were 7.6% and 25.6% (see table). One-way analysis of variance (ANOVA) indicated that the effect of degree of milling on EMC of adsorption and desorption was significant at 5% and 0.5% levels of significance.

EMC values for desorption were higher for milled rice than for unmilled rice (8.6% at 20 °C and 0.11 relative humidity). The EMC generally decreased with an increase in temperature and generally increased with a rise in relative humidity for both adsorption and desorption processes. Differences varied with level of relative humidity and temperature. At constant relative humidity, hysteresis was higher at lower temperature. For example, at a relative humidity of 0.11, the difference between desorption and adsorption EMC for 3.8% milled rice was 2.1%, 1.1%, and 0.4%, at temperatures of 20, 30, and 40 °C respectively. Similar effects were also observed for other relative humidities.

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Equilibrium moisture content of milled rice at different temperatures and relative humidities. Pantnagar India.

Temperature (°C)	Relative humidity	Adsorption				Desorption			
		0.0	3.8 ^a	6.6 ^a	10.3 ^a	0.0	3.8 ^a	6.6 ^a	10.3 ^a
20	0.11	8.0	7.3	7.6	7.6	8.6	9.4	9.0	9.2
	0.34	12.4	12.4	12.6	13.6	14.3	14.4	15.2	15.8
	0.44	14.2	14.4	14.4	14.8	16.0	16.2	16.6	17.0
	0.59	16.8	17.3	17.0	16.9	18.6	18.6	18.6	19.1
	0.76	19.8	20.4	20.2	20.0	21.4	21.8	22.0	21.8
	0.80	20.6	21.2	21.4	21.2	22.2	22.8	23.0	22.8
	0.91	24.2	24.2	25.3	^b	25.6	26.2	26.0	^b
	0.11	7.4	6.9	6.8	6.7	8.2	8.0	8.3	8.6
	0.33	13.4	11.8	12.2	13.0	14.6	13.2	14.2	15.6
	0.44	15.0	14.0	14.0	14.5	16.2	15.3	16.2	16.4
30	0.63	17.6	17.0	18.6	18.8	18.4	18.2	20.0	20.7
	0.76	20.1	19.2	20.6	20.1	20.8	20.6	21.8	22.2
	0.80	21.0	21.0	21.4	21.0	21.8	22.4	22.8	22.4
	0.96	^b	^b	26.2	^b	^b	^b	27.0	^b
	0.11	7.0	7.2	6.6	6.0	7.6	7.6	8.0	8.0
	0.32	12.1	11.8	11.8	12.2	13.0	12.6	13.4	13.2
	0.43	14.4	13.6	13.8	13.4	14.8	14.4	15.2	14.5
40	0.63	17.8	16.8	18.2	17.4	18.6	18.0	19.0	18.4
	0.75	20.4	19.6	20.4	19.8	20.8	20.9	21.4	20.9
	0.80	21.0	20.6	21.4	20.6	21.6	21.2	22.2	21.8
	0.91	23.0	23.4	24.6	24.0	23.6	24.6	24.8	25.0

^aDegree of milling (%). ^bNo observations due to mold growth.