Changes in Physicochemical Properties of Infrared Dried Rice During Storage

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Introduction

Rice is usually dried and stored to satisfy the need of continuous consumption. During storage, some changes in physicochemical properties of rice may occur and result in the alteration on rice appearance, flavor, and eating quality. Moreover, the physicochemical properties, including gelatinization and pasting properties, have a strong correlations with cooking and eating quality of rice. The effect of drying, milling, and aging on physicochemical changes of rice have been well investigated.

Infrared (IR) radiation heating followed by tempering treatment and natural cooling has shown a great promise to achieve high heating and drying rates and good milling quality of rough rice. Correspondingly, effective disinfestation, disinfection and stabilization of rough and brown rice can be achieved. Thus, furthermore study on effect of IR drying on physicochemical prosperities of rice during storage is needed.

Objectives

- Determine the impact of drying methods, including infrared, hot air and ambient air, on physicochemical properties of rice.
- Investigate the changes of physicochemical properties rice under accelerated storage condition of rough and brown .

Materials and Methods

Freshly harvested medium grain rice, variety M206, with a initial moisture content (IMC) of 25.03±0.01% in dry basis or 20.02% in wet basis, obtained from Farmer's Rice Cooperative (West Sacramento, CA) was used for conducting this study. The rice sample was split into three equal portions and prepared for IR drying (IRD), hot air drying (HAD) and ambient air drying (AAD). For IRD, the samples were heated using a catalytic emitter to temperature of 60°C followed by tempering treatment for 4 h and natural cooling. The samples dried using IR, HA, and AA drying methods were divided into two portions. One was used as rough rice and the other one was dehulled to produce brown rice. The rough rice and brown rice samples were stored at accelerated storage conditions (temperature of 35 °C and relative humidity of 65±3.0%) for ten months. The moisture, chroma, gelatinization properties and pasting properties were investigated over the storage time.

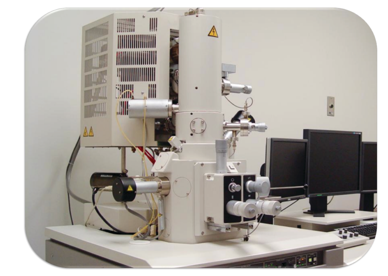
IR drying

Rice storage

Chroma meter

DSC (gelainization)

RVA (Pasting)



SEM (Microstructure)

Results

High heating and drying rates were achieved under IRD compared to HAD and AAD. For IRD, It took only 58 s to heat rough rice to 60 °C with corresponding moisture removal of 2.17 percentage points. The total moisture removal after tempering and natural cooling reached 3.37 percentage points. The final moisture content reached 15.92% (13.73% in wet basis) after 6 h of subsequent AA drying. Comparatively, 3 passes of 20 min HA drying and 4 h tempering dehydrated the rice from a MC of 25.03±0.01% to 16.13±0.12%. For continuous AA air drying method, 18 h was used to decrease the MC of rice to 16.15±0.09%.

There were no significant differences ($p<0.05$) between the a* and b* values of rice samples dried by using IR, HA and AA methods. The a* and b* values increased over storage for all samples dried with tested drying methods (Figure 1). This increase may be related to color leaching, lipid oxidation and Mailard reaction during the storage.

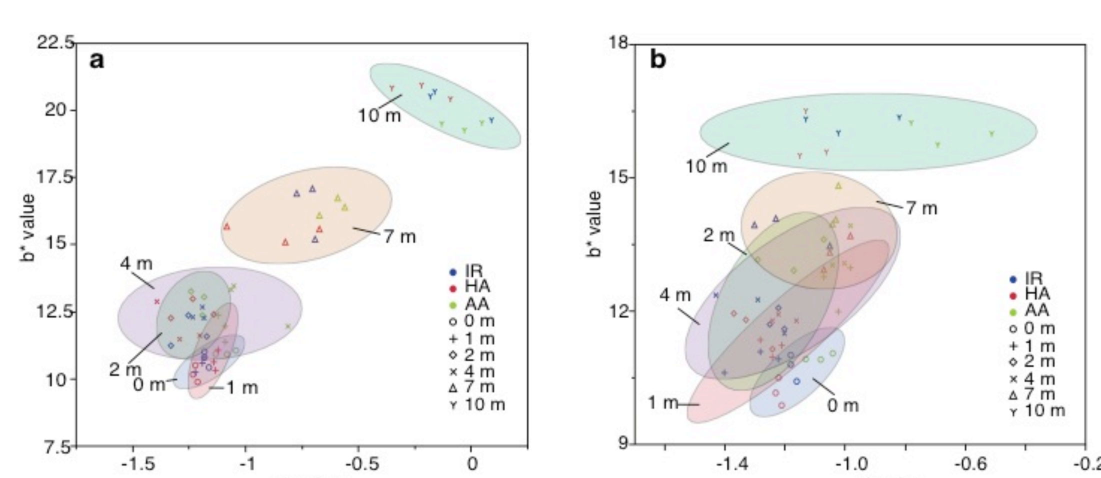


Figure 1 Effect of IR heating on color characteristics over storage time of milled rice from stored rough (a) and brown (b) rice.

The pasting properties for rice dried using IR, HA and AA showed similar trend during storage. Compared to the stored rough rice samples dried by using HA and AA, the rice dried by using IR had lower peak viscosity (PV) and final viscosity (FV). Comparatively, the storage time had an obvious influence on the pasting properties of the rice samples. The changes in pasting properties of the brown rice were slightly different from those of rough rice. The highest PV value of brown rice samples was higher than rough rice. Additionally, brown rice samples had less decrease for BD and less growth increments for SB viscosity than rough rice.

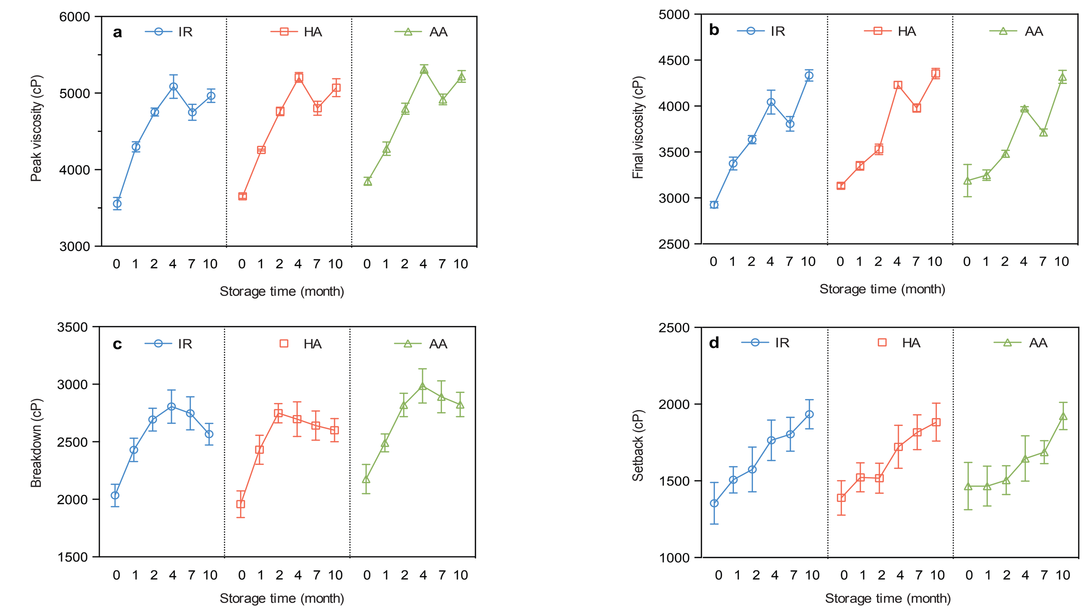


Figure 2 Peak viscosity (a), final viscosity (b), breakdown (c) and setback (d) of white rice flour milled from rough rice dried by IRD, HAD and AAD during the storage

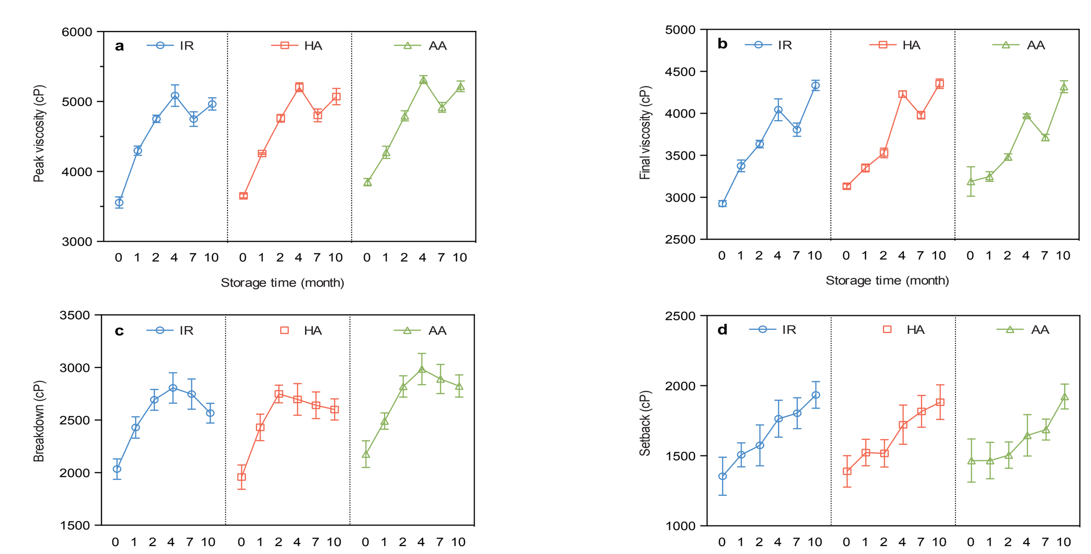


Figure 3 Peak viscosity (a), final viscosity (b), breakdown (c) and setback (d) of white rice flour milled from brown rice dried by IRD, HAD and AAD during the storage

In accordance with the similar values of T_o, T_p and T_c, and the enthalpy of gelatinization (ΔH), the thermal properties of dried rice samples were not significantly influenced by IR. ΔH of all samples dried with IR, HA and AA significantly increased ($p<0.05$) during storage.

Table 1 Effects of drying methods and storage time on thermal properties of rough rice, including the onset temperature (T_o), peak temperature (T_p), conclusion temperature (T_c) and enthalpy of gelatinization (ΔH).

Drying method	Storage duration (month)	T_o (°C)	T_p (°C)	T_c (°C)	ΔH (kJ/g rice flour)
Infrared	0	63.32±0.23	68.74±0.34	73.77±0.32a	7.60±0.31a
	1	63.50±0.63	69.13±0.25	74.30±0.53abc	9.26±0.62ab
	2	63.92±0.34	69.42±0.43	74.54±0.34abc	9.51±0.51b
	4	64.19±0.36	69.78±0.29	74.78±0.44bc	10.00±0.63b
	7	64.19±0.30	69.68±0.36	74.43±0.47ab	10.29±0.63b
	10	63.64±0.32	69.15±0.33	74.27±0.42abc	9.01±0.88ab
Hot air	0	63.26±0.33	68.76±0.34	73.88±0.23abc	7.80±0.46a
	1	63.61±0.10	68.97±0.13	74.47±0.20abc	8.62±0.46ab
	2	63.92±0.48	69.41±0.46	74.75±0.35abc	9.50±0.50b
	4	64.00±0.54	69.70±0.58	74.85±0.31c	9.74±0.72b
	7	63.90±0.44	69.74±0.41	74.41±0.24abc	10.30±0.56b
	10	63.31±0.25	69.18±0.39	74.31±0.32abc	9.22±0.48ab
Ambient air	0	63.26±0.24	68.89±0.32	73.84±0.45ab	7.71±0.62a
	1	63.46±0.59	68.87±0.13	74.59±0.06ab	8.62±0.61ab
	2	63.82±0.38	69.27±0.28	74.64±0.23ab	9.16±0.41ab
	4	64.16±0.38	69.79±0.30	74.82±0.10bc	10.04±0.57b
	7	63.86±0.40	69.56±0.39	74.49±0.22abc	10.00±0.35b
	10	63.59±0.52	69.10±0.41	74.14±0.26abc	9.19±0.30ab

During storage, the To, Tp and Tc of brown rice showed a trend similar to rough rice. To and Tp increased in the first 4 months, became stable for several months and then decreased at month 10. Tc increased to the peak at month 4 followed with a consistent drop till month 10. ΔH increased to 10.1 J/g rice flour till month 7 and then reduced to 9 J/g rice flour at month 10. Drying methods had no notable influence on the change behavior of thermal properties.

Table 2 Effects of drying methods and storage time on thermal properties of brown rice, including the onset temperature (T_o), peak temperature (T_p), conclusion temperature (T_c) and the enthalpy of gelatinization (ΔH).

Drying method	Storage duration (month)	T_o (°C)	T_p (°C)	T_c (°C)	ΔH (kJ/g rice flour)
Infrared	0	63.32±0.23ab	68.74±0.34	73.77±0.32	7.60±0.31a
	1	63.44±0.36ab	68.72±0.35	73.84±0.36	9.39±0.44ab
	2	63.38±0.26ab	69.15±0.20	74.31±0.38	10.46±0.37bc
	4	63.52±0.35ab	69.36±0.50	74.43±0.56	10.68±0.11bc
	7	63.86±0.40ab	69.43±0.43	74.62±0.29	10.70±0.71bc
	10	64.21±0.38b	69.34±0.47	74.60±0.48	10.57±0.22bc
Hot air	0	63.26±0.33a	68.76±0.34	73.88±0.23	7.80±0.46a
	1	63.52±0.32ab	68.72±0.33	74.10±0.43	9.86±0.77b
	2	63.19±0.17a	68.90±0.22	73.98±0.24	10.30±0.42bc
	4	63.67±0.10ab	69.13±0.24	74.31±0.19	10.39±0.93bc
	7	63.95±0.33ab	69.06±0.47	74.57±0.29	10.98±0.87c
	10	63.97±0.14ab	69.48±0.15	74.55±0.52	10.77±0.48bc
Ambient air	0	63.26±0.24a	68.89±0.32	73.84±0.45	7.71±0.62a
	1	63.15±0.33a	68.80±0.05	73.98±0.04	9.16±0.73ab
	2	63.38±0.27ab	69.24±0.32	73.91±0.15	10.77±0.56bc
	4	63.86±0.40ab	69.00±0.36	74.44±0.34	10.26±0.57bc
	7	63.88±0.25ab	69.17±0.18	74.51±0.19	10.67±0.73bc
	10	63.81±0.33ab	69.36±0.54	74.82±0.33	10.66±0.63bc

Conclusions

This study demonstrated that the drying of rough rice using IR heating to 60°C followed by tempering treatment for 4 h and natural cooling had no adverse effect on physicochemical properties of rice stored as rough or brown. This may lead to apply infrared heating as an alternative drying method to conventional methods to achieve a high drying efficiency and good milling quality without affecting the cooking and eating quality for rice.

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