# Study on the safe moisture content during paddy rice storage

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## Abstract

The impact of temperature and moisture content on mycotoxin generation of hsien rice and japonica rice during storage were investigated with ergosterol as an indicator. The results showed that the safe moisture contents are 13.5% and 14.0% for hsien rice and japonica rice respectively, which should be used as the guide for storage of high moisture content rice. Safe moisture content of paddy rice storage in warehouse should be validated experimentally.

Keywords: paddy rice storage, ergosterol, moisture content, temperature, hsien rice, japonica rice

## 1. Introduction

Recently, a series of grain storage technologies such as grain drying technology, ventilation drying technology and temperature controlling grain storage technology have been developed. High moisture grain is often brought in directly to grain depots. Paddy rice is an important crop in China. Research on the safe storage of paddy rice is necessary to ensure quality.

## 2. Materials and Methods

The instruments used were as follows: liquid chromatograph (5510 pump produced by Water company), 7725 sample injector (Luo Danny company), Dual wavelength UV detector (Water company), 6110 type electronic balance (Tecator company), Whirlwind milling (40 mesh sieve plate, Tecator company), artificial climate cabinet for cultivating, refrigerator (with icebox), SK1200H type ultrasonic cleaner, thermostatic waterbath: temperature could be controlled within 80g, °C, riffle sampler. Reagents were: hexane, methanol &isopropanol belong to chromatographic pure, caustic potash belongs to analytical reagent, ergosterin (standard substance). Sampling was done as follows: 100 kg nonglutinous rice are sampled from Sichuan province, China in November, 2011, normal smell and luster, non-mildew, middle-level quality, initial content of coprocampesterol is between 1.76 mg/kg～1.93mg/kg. 100 kg round-grained non-glutinous rice are sampled from Jiangsu province, China in December, 2011, normal smell and luster, non-mildew, middle-level quality, initial content of coprocampesterol is between 1.68 mg/kg～1.92mg/kg.

Pre-treatments include cleaning, edulcoration, determining moisture content, drying the two types of paddy to 2.1% and 13.0% respectively. Samples were taken according to Table 1.

**Table 1** Moisture content of Sample.

| | | | | | | |
|---|---|---|---|---|---|---|
| Nonglutinous rice | Moisture-content（%） | 12 | 13 | 14 | 15 | 15.5 |
| | Weight（Kg） | 20 | 20 | 20 | 20 | 20 |
| Round-grained nonglutinous rice | Moisture-content（%） | 13 | 13.5 | 14.5 | 15.5 | 16.5 |
| | Weight（Kg） | 20 | 20 | 20 | 20 | 20 |

Table 2 shows non-glutinous rice, round-grained non-glutinous rice with different moisture content and their experimental storage temperatures.

**Table 2** Storage Conditions.

| Species | Storage Temperature (°C) | Moisture-content （%） | | | | |
|---|---|---|---|---|---|---|
| Nonglutinous rice | 15 | 12 | 13 | 14 | 15 | 15.5 |
| | 20 | 12 | 13 | 14 | 15 | 15.5 |
| | 25 | 12 | 13 | 14 | 15 | 15.5 |
| | 30 | 12 | 13 | 14 | 15 | 15.5 |
| Round-grained nonglutinous rice | 15 | 13 | 13.5 | 14.5 | 15.5 | 16.5 |
| | 20 | 13 | 13.5 | 14.5 | 15.5 | 16.5 |
| | 25 | 13 | 13.5 | 14.5 | 15.5 | 16.5 |
| | 30 | 13 | 13.5 | 14.5 | 15.5 | 16.5 |

Sampling was done each month to detect coprocampesterol content in samples according to Chinese National Standards (GB/T25221).

## 3. Results and Discussion

Coprocampesterol content changes during the process of paddy rice storage (Table 3).

Coprocampesterol content in non-glutinous rice stored at different temperature and humidity. (Table 3)

**Table 3** Coprocampesterol content change during the process of Nonglutinous unhulled rice storage.

| No. | Temperature (°C) | Moisture content (%) | Period (day) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 0 | 30 | 60 | 90 | 120 | 150 |
| 1 | 15.0 | 12.1 | 1.76 | 1.98 | 1.85 | 1.93 | 1.72 | 1.84 |
| 2 | 15.0 | 13.2 | 1.88 | 1.76 | 1.75 | 1.94 | 2.01 | 1.83 |
| 3 | 15.0 | 14.3 | 1.86 | 1.83 | 1.91 | 1.79 | 1.99 | 2.07 |
| 4 | 15.0 | 15.0 | 1.81 | 1.93 | 2.29 | 2.72 | 3.19 | 3.61 |
| 5 | 15.0 | 15.6 | 1.85 | 2.11 | 2.81 | 3.75 | 4.68 | 5.62 |
| 6 | 20.0 | 12.2 | 1.79 | 1.92 | 1.85 | 1.74 | 1.83 | 1.97 |
| 7 | 20.0 | 13.3 | 1.87 | 1.89 | 1.76 | 1.94 | 1.71 | 1.89 |
| 8 | 20.0 | 14.1 | 1.91 | 1.95 | 2.23 | 2.57 | 2.91 | 3.27 |
| 9 | 20.0 | 15.2 | 1.84 | 2.07 | 2.73 | 3.58 | 4.41 | 5.16 |
| 10 | 20.0 | 15.5 | 1.86 | 2.35 | 3.98 | 5.61 | 6.87 | 9.13 |
| 11 | 25.0 | 12.1 | 1.73 | 1.92 | 1.75 | 1.87 | 1.99 | 1.77 |
| 12 | 25.0 | 13.0 | 1.92 | 1.9 | 1.94 | 1.77 | 2.01 | 1.85 |
| 13 | 25.0 | 14.2 | 1.85 | 1.91 | 2.41 | 2.89 | 3.41 | 3.94 |
| 14 | 25.0 | 15.1 | 1.9 | 2.15 | 3.02 | 4.28 | 5.62 | 7.03 |
| 15 | 25.0 | 15.6 | 1.88 | 2.93 | 5.53 | 8.53 | 10.84 | 14.32 |
| 16 | 30.0 | 12.3 | 1.93 | 1.88 | 1.75 | 1.86 | 2.07 | 1.79 |
| 17 | 30.0 | 13.0 | 1.89 | 1.92 | 1.97 | 1.81 | 1.69 | 1.92 |
| 18 | 30.0 | 14.4 | 1.86 | 2.09 | 3.35 | 5.02 | 6.74 | 8.43 |
| 19 | 30.0 | 15.1 | 1.91 | 3.39 | 6.37 | 10.09 | 12.83 | 15.58 |
| 20 | 30.0 | 15.5 | 1.93 | 3.97 | 7.58 | 11.46 | 14.59 | 17.93 |

Fig. 1 shows the variation trends which are summarized from the results of Table 3.

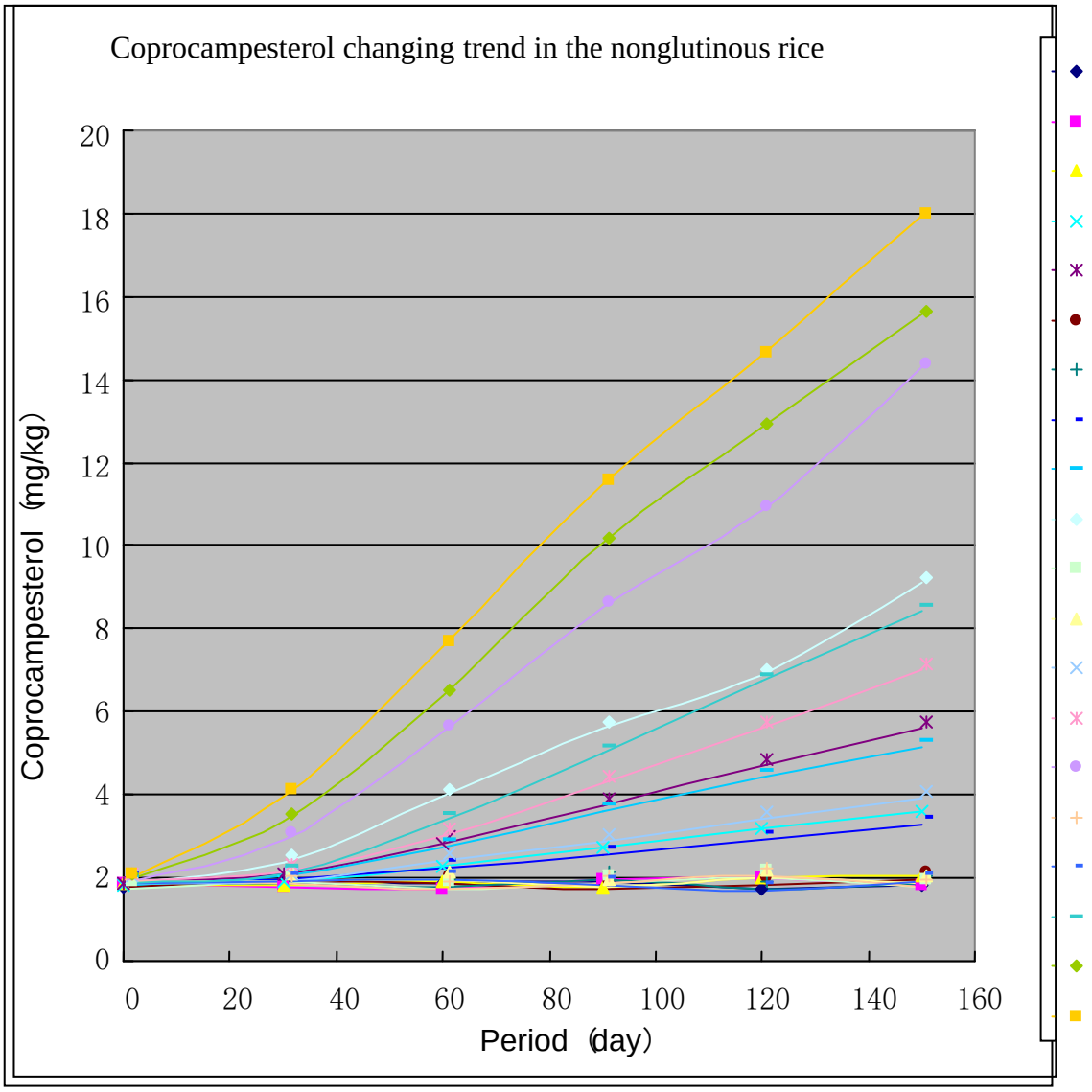


**Figure 1** Coprocampesterol content change during the process of nonglutinous rice storage.

Table 4 shows coprocampesteral content in round-grain non-glutinous unhulled rice.

**Table 4** Coprocampesterol content change during the process of Round-grained non-glutinous unhulled rice storage.

| No. | Moisture content (%) | Temperature (°C) | Period (day) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 0 | 30 | 60 | 90 | 120 | 150 |
| 21 | 13.0 | 15 | 1.68 | 1.93 | 1.77 | 1.88 | 1.78 | 1.89 |
| 22 | 13.1 | 20 | 1.72 | 1.87 | 1.66 | 1.95 | 1.79 | 1.83 |
| 23 | 13.0 | 25 | 1.89 | 1.74 | 1.94 | 1.76 | 1.85 | 1.97 |
| 24 | 12.9 | 30 | 1.77 | 1.65 | 1.81 | 1.77 | 1.9 | 1.86 |
| 25 | 13.6 | 15 | 1.92 | 1.76 | 1.88 | 1.69 | 1.75 | 1.91 |
| 26 | 13.6 | 20 | 1.75 | 1.84 | 1.62 | 1.94 | 1.85 | 1.74 |
| 27 | 13.6 | 25 | 1.81 | 1.74 | 1.66 | 1.83 | 1.72 | 1.85 |
| 28 | 13.6 | 30 | 1.8 | 1.69 | 1.75 | 1.62 | 1.91 | 1.79 |
| 29 | 14.5 | 15 | 1.79 | 1.87 | 1.64 | 1.96 | 1.88 | 1.72 |
| 30 | 14.5 | 20 | 1.82 | 1.68 | 1.94 | 2.01 | 2.13 | 2.41 |
| 31 | 14.5 | 25 | 1.74 | 1.92 | 2.17 | 2.41 | 2.86 | 3.39 |
| 32 | 14.4 | 30 | 1.76 | 2.07 | 2.65 | 3.39 | 4.22 | 5.14 |
| 33 | 15.6 | 15 | 1.83 | 2.08 | 2.41 | 2.89 | 3.35 | 3.78 |
| 34 | 15.6 | 20 | 1.75 | 2.13 | 2.86 | 3.71 | 4.65 | 5.49 |
| 35 | 15.5 | 25 | 1.78 | 2.25 | 3.17 | 4.35 | 5.72 | 7.05 |
| 36 | 15.6 | 30 | 1.89 | 3.21 | 6.52 | 8.84 | 12.24 | 15.39 |
| 37 | 16.5 | 15 | 1.84 | 2.37 | 3.42 | 5.03 | 6.87 | 8.63 |
| 38 | 16.6 | 20 | 1.76 | 3.59 | 6.71 | 9.26 | 12.66 | 15.81 |
| 39 | 16.5 | 25 | 1.83 | 4.83 | 9.55 | 13.36 | 18.16 | 22.72 |
| 40 | 16.5 | 30 | 1.75 | 7.92 | 16.64 | 23.69 | 31.58 | 38.96 |

Similarly, Fig. 2 shows the trends from Table 4.

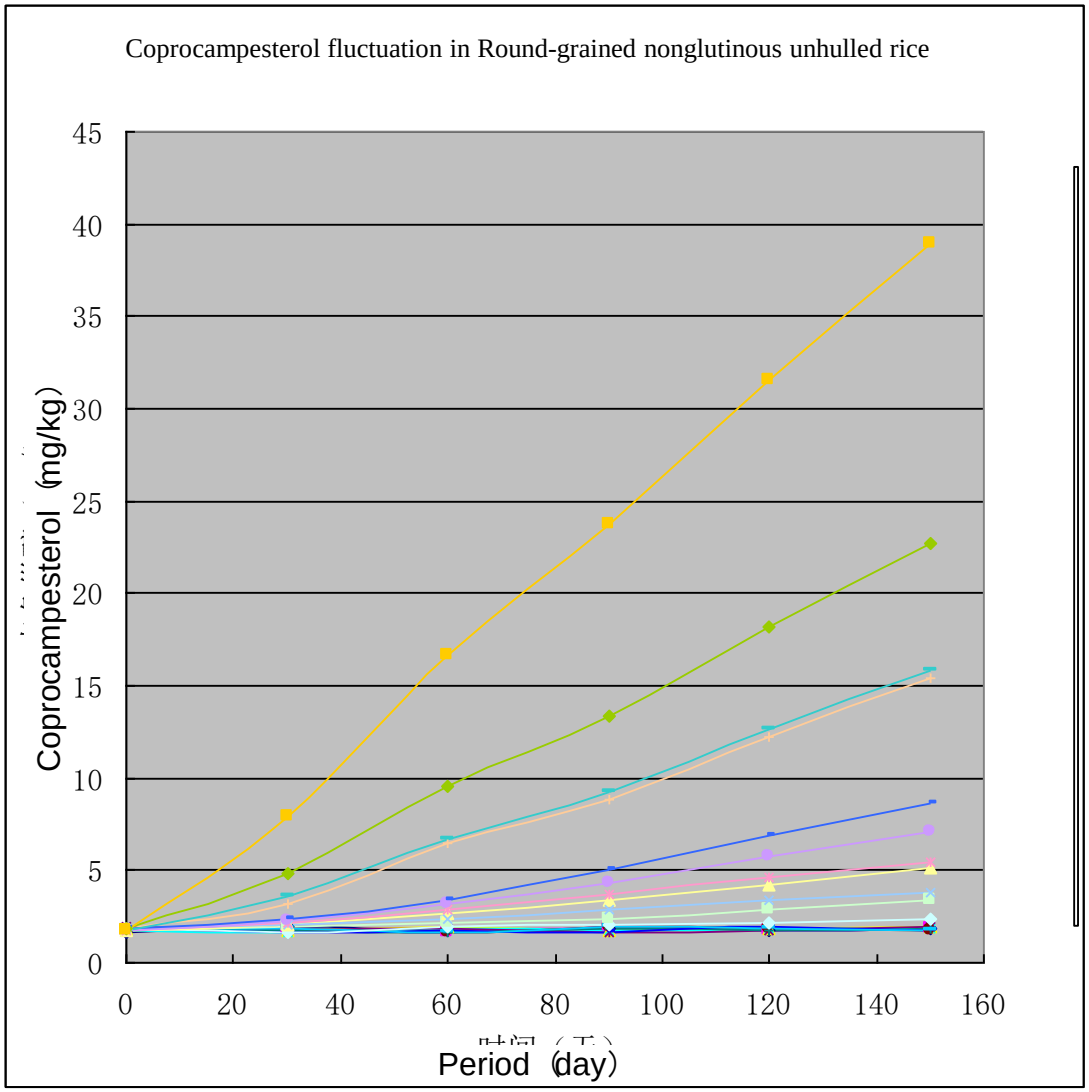


**Figure 2** Coprocampesterol fluctuation in round-grained non-glutinous unhulled rice.

Tables 5 and 6 show the equations for the safe storage period.

**Table 5** Safety storage period of the non-glutinous rice.

| Moisture-content(%) | Temperature(°C) | Computational Formula | Safety period (day) |
|---|---|---|---|
| 15.5 | 30 | y = 0.1164x + 0.627 | 46 |
| | 25 | y = 0.0936x + 0.003 | 64 |
| | 20 | y = 0.0548x + 0.653 | 98 |
| | 15 | y = 0.0296x + 1.127 | 165 |
| 15 | 30 | y = 0.1028x + 0.4 | 54 |
| | 25 | y = 0.0412x + 0.712 | 128 |
| | 20 | y = 0.0262x + 1.232 | 182 |
| | 15 | y = 0.0142x + 1.47 | 319 |
| 14 | 30 | y = 0.0536x + 0.305 | 106 |
| | 25 | y = 0.0169x + 1.394 | 273 |
| | 20 | y = 0.0111x + 1.59 | 397 |
| | 15 | y = 0.0019x + 1.75 | 2237 |

**Table 6** Safety storage period of the round-grained non-glutinous rice.

| Moisture-content（%） | Temperature（℃） | Computational Formula | Safety period（day） |
|---|---|---|---|
| 16.5 | 30 | y = 0.2567x + 0.652 | 21 |
| | 25 | y = 0.148x + 0.407 | 38 |
| | 20 | y = 0.1013x + 0.489 | 54 |
| | 15 | y = 0.0532x + 0.473 | 104 |
| 15.5 | 30 | y = 0.1003x + 0.216 | 58 |
| | 25 | y = 0.0405x + 0.863 | 127 |
| | 20 | y = 0.0284x + 1.215 | 168 |
| | 15 | y = 0.0145x + 1.6 | 303 |
| 14.5 | 30 | y = 0.0257x + 1.181 | 188 |
| | 25 | y = 0.0121x + 1.461 | 375 |
| | 20 | y = 0.0055x + 1.539 | 811 |
| | 15 | y = -1E-17x + 1.81 | |

We could see from tables 5 and 6 that with the decreasing moisture content and temperature of the paddy rice, the safe storage period is longer. Field validation of these laboratory tests are currently underway.