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The above results show that the rapid detection technology of paddy's degree of freshness has great applicability to distinguish fresh and non-fresh paddy in China.

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Fumigation with Ph3 using automatic generation - Presentation of results of recent trials

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Abstract

Fumigation is essential part of preservation of grains, other edible commodity and perishables. Phosphine is most commonly used fumigant since more than 65 years. It is now practically the only fumigant and most commonly used. While fumigating with conventional metal phosphide formulations most common problems or concerns are operator safety, laborious to apply, gas retention in structure, uniformity of gas concentration in the structure, solid residues left in the commodity, limitations in ambient conditions to apply the fumigant and others. Bad fumigation practices lead to failed fumigations. These are blamed on insect resistance. Scientists have noted higher tolerance levels, but not resistance to phosphine. To address all the concerns referred, and limitations of conventional fumigants, we have developed a Phosphine generator and a suitable formulation for use with the same. This is a fully automatic machine. The formulation is granular and dust free. Those using our generators have stopped using conventional formulations of phosphine. The paper presents merits of technology, results of trials in various locations and on different commodity. This is the only system, which ensures uniform distribution of gas in entire structure to give 100 % guaranteed fumigation results.

Browning Mechanism and Process Optimization during MaizeMaize KX7349 Drying

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Abstract

Browning of KX7349 maize during drying occurred mainly in the pericarp layer. Browning was caused by oxidation of water soluble matter in the pericarp layer. Moisture content had no significant influence on browning rate. Drying temperature, drying time and drying method (vacuum drying or hot-air drying) had significant influence on the browning rate. Through lab research, a prediction model for the relationship between browning rate and drying air temperature was developed. Total drying time is $y=-13.086+0.289X_1+1.045X_2$, where y is the browning rate（%）, X_1 is drying temperature（℃）, X_2 is total drying time（h）, the value range of X_1 was 30～80, the value range of X_2 was 2～10. The concurrent and counter current dryer was applied in Nenjiang to optimize the drying process. The hot air temperature in each drying stage was reduced. When the hot air temperature of the 1st, 2nd, 3rd drying stage was reduced to 95°C,75°C,60°C respectively, the browning rate was reduced to 15%～16%. Keeping the hot air temperature constant at each drying stage, by drying twice, the browning rate was reduced to 4%～6%.

Keywords: KX7349, drying, browning mechanism

1. Introduction

Maize is one of the most important cereal grains in the world. It is cultivated worldwide. America and China are the main producers of maize, which yielded 57.5% of maize production in 2015 in the world. In China, maize is cultivated widely. According to geographical and climatic features, there are six maize planting areas. Among them, the northern spring maize region accounts for 30% of maize production in China. This area includes Heilongjiang, Jilin, Liaoning and Inner Mongolia. When the maize is harvested in this area, the temperature decreases rapidly, maize cannot be sun-dried sufficiently. The moisture content is high. Especially in Heilongjiang province, on some occasions, the MC is up to 30% wet-basis. Rapid moisture-removal technology is needed to achieve a safe stoage moisture level and to inhibit the growth of microorganisms. Hot-air drying is an appropriate approach.

Maize KX7349 is a variety bred by KWS, a German seed company. It is planted widely in Inner Mongolia, Heilongjia and Jilin. After drying, many maize kernels undergo browning, which results in a rapid drop in price. It is rejected by the food industry if premium quality is needed.

This phenomenon motivates us to find the reasons and explore methods of improving the process of drying. Studies were conducted to determine the factors affecting browning and the separation and extraction of browning materials.

2. Materials and Methods

Materials: KX7349 maize, harvested in 2014, provided by Heilongjiang province.

Main instruments: DHG-9146A electric constant temperature drying oven (Shanghai Yiheng Science Instruments Co., Ltd.); DZF-6090 vacuum drying oven (Shanghai Yiheng Science Instrument Co., Ltd.); AL204 electronic scales (Shanghai Mettler-Toledo Instruments Co., Ltd.); HSNT25 concurrent and counter current dryer (COFCO engineering Co., Ltd.); HPLC-ELSD analyzer with a sugar analysis column (Agilent Technologies Co., Ltd.).

Main methods:

- Browning rate

Browning rate (%) = Weight of browning shelled maize×100/ Total weight of shelled maize

- Main factors affecting browning rate

The KX7349 shelled maize at 30% MC was dried by the electric constant temperature drying oven at 30°C, 40°C, 50°C, 60°C, 70°C and 80°C, respectively. The browning rate was tested every two hours.

The KX7349 shelled maize with original MCs of 14%, 20%, 25% and 30% was dried at 80°C. The browning rate was tested every half an hour to analyze the effect of MC on the browning rate.

KX7349 maize growing in different areas was tested to evaluate the effect of growing area on browning rate.

Also, two different drying methods, namely hot-air drying and vacuum drying, were compared.

- Separation and extraction of browning materials

The maize pericarp was peeled off the kernel. The maize pericarp and the kernel were dried at 100°C for 30 min to test the colour changes. The pericarp was also treated in distilled water for 2 hours and then dried for 30 min at 100°C. Browning and non-browning shelled maize were analyzed by the HPLC-ELSD analyzer equipped with a sugar analysis column.

- Drying process optimization

The KX7349 shelled maize at 30% MC was dried by the electric constant temperature drying oven at 30°C, 40°C, 50°C, 60°C, 70°C and 80°C, respectively. The browning rate was tested every two hours.Maize

The concurrent and counter current dryers were applied in Nenjiang to optimize the drying process. The initial MC of maize was 27%～31%. The drying process included two concurrent flow stages, one counter current flow stage and one cooling stage.

3. Results

- Main factors affecting browning rate

Table 1 shows the results of browning rate of KX7349 maize being dried at different temperatures and drying times. The browning rate increased as both drying time and temperature increased. At 80℃, after 10 hours the browning rate was highest at 19.99%. At 80℃, the browning rate increased much more rapidly as compared to drying at the other temperatures. The analysis showed that the drying time and temperature significantly affected the browning rate ($p < 0.01$).

Table 1. Browning rate (%) at different drying temperatures and times.

	2 h	4 h	6 h	8 h	10 h
30℃	1.13±0.12	1.47±0.05	2.01±0.02	3.00±0.02	5.01±0.01
40℃	1.51±0.09	2.00±0.09	3.05±0.15	4.13±0.05	5.81±0.09
50℃	3.96±0.13	6.96±0.14	7.84±0.05	8.94±0.14	11.93±0.07
60℃	6.07±0.14	7.98±0.03	9.99±0.09	13.87±0.06	17.87±0.12
70℃	7.96±0.22	10.02±0.07	12.97±0.06	16.96±0.06	19.98±0.10
80℃	9.93±0.14	13.05±0.09	16.82±0.06	19.87±0.12	19.99±0.02

Table 2 shows changes in the browning rate of different original MC maize being dried at 80℃. Regardless of the original maize MC, the browning rate increased with drying time. maizeAlso, the analysis showed that the moisture content of maize had no effect on the browning rate (p=0.647).

Table 2. Browning rate (%) of maize with different MCsmaize.

MC (%)	0.5 h	1 h	1.5 h	2 h
14	2.56±0.09	5.40±0.01	7.24±0.05	9.23±0.06
20	2.44±0.04	5.33±0.12	7.29±0.09	9.29±0.07
25	2.56±0.15	5.26±0.11	7.31±0.05	9.23±0.09
30	2.59±0.12	5.33±0.09	7.28±0.03	9.30±0.04

Table 3 shows the browning rates of maize from two different areas being dried at 90℃. At the same drying conditions, the browning rate of the maize from Nenjiang area was much higher than the maize from Qitaihe area. The analysis showed growing area of maize had a significant effect ($p < 0.01$). Because the annual accumulated temperature was different in these two places, the maturity level was different for maize from these two places.

Table 3. Browning rate (%) of maize from different areas.

Drying method	Nenjiang	Qitaihe
Hot-air drying 90℃, 30 min	43.73±0.42a	6.70±0.13b
Hot-air drying 90℃, 1 h	72.50±0.19a	25.12±0.15b

Table 4 shows the browning rates from the different drying methods. After 30 min of drying, the browning rates by vacuum and hot-air drying were 6.24% and 43.72%, respectively. After 1 h, the browning rate by vacuum drying was 6.03%, while the browning rate by hot-air drying was 72.50%. Compared with hot-air drying, vacuum drying could obviously inhibit maize browning. This indicated the maize underwent browning due to the participation of oxygen.

Table 4. Browning rate （%） for maize dried by two different methods.

Drying method	Browning rate (%)
Vacuum drying 90℃，30 min	6.24±0.24
Vacuum drying 90℃，1 h	6.03±0.12
Hot-air drying 90℃，30 min	43.73±0.42
Hot-air drying 90℃，1 h	72.50±0.19

- Separation and extraction of browning materials

Fig. 1. Before drying.

Fig. 2. After drying.

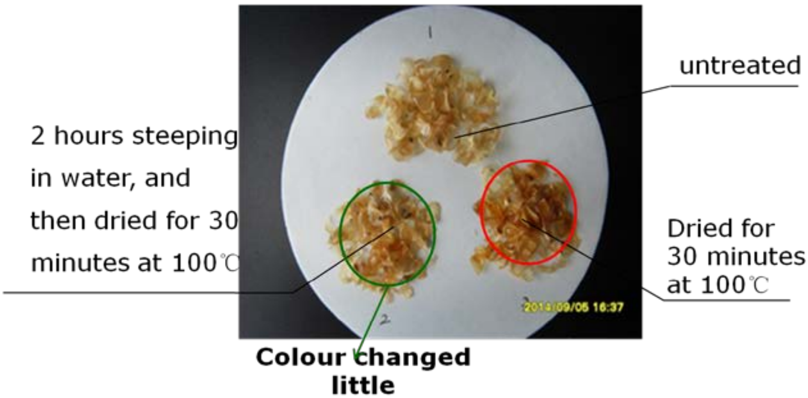
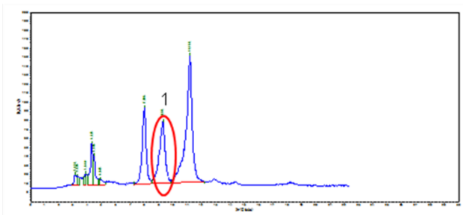


Fig. 3. Dissolution characteristics of browning materials.

The maize pericarp was peeled off the kernel. After drying, the maize pericarp underwent browning, however, the endosperm and embryo changed only slightly (Fig. 1 and Fig. 2). This indicated that most of the browning materials were in the pericarp. The pericarp was treated in distilled water for 2 hours, and then dried for 30 minutes at 100°C. Compared with the untreated pericarp after being dried at the same condition, the colour changed slightly, indicating that the browning materials were soluble in the water (Fig. 3).

From the HPLC fingerprint spectrums (Fig. 4), Peak 1 was found. The retention time of Peak 1 corresponded to that of glucose. The results showed that the glucose content of the browning in maize was twice as much of the non-browning maize. From this point, we deduced that browning might be caused by Mailard reaction. In addition, we concluded the following new findings: 1. browning materials were mainly in maize pericarp and soluble in water, 2. Browning was induced by oxidation of the water-soluble materials and 3. glucose content was higher in browning maize than that in non-browning maize without drying.



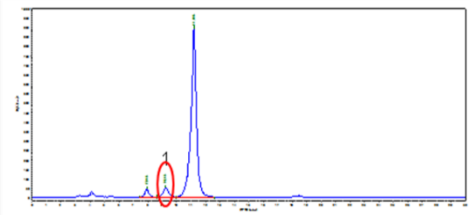


Fig. 4. Sample of browning Fig. 5. Sample of non-browning

- Drying process optimization

From the results of the above analysis, we found that main influence factors of browning rate were drying temperature, drying time and drying method. Because vacuum drying has not been applied commercially in practice, drying temperature and drying time became the most important factors determining the maize browning rate.

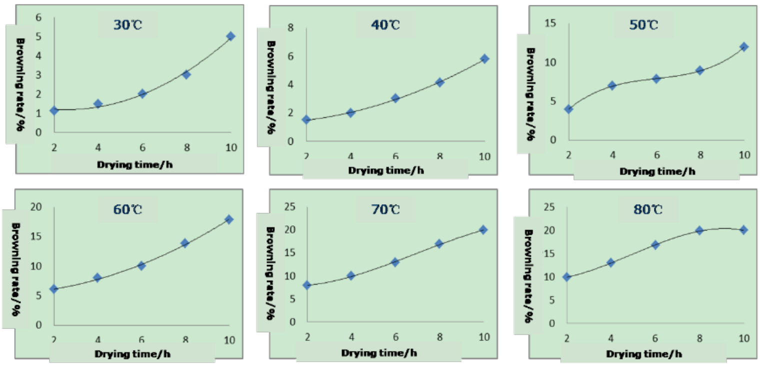


Fig.6. Changes in browning rate with drying time and temperature.

Fig. 6 shows changes in browning rate with drying time and drying temperature. The browning rate increased with drying time for every drying temperature. During the early drying period, the slope of the curve was very steep for the higher temperature, compared with the lower temperature, suggesting that drying temperature had more obvious effect on browning rate than drying time.

Fig. 7. Concurrent and counter current dryer.

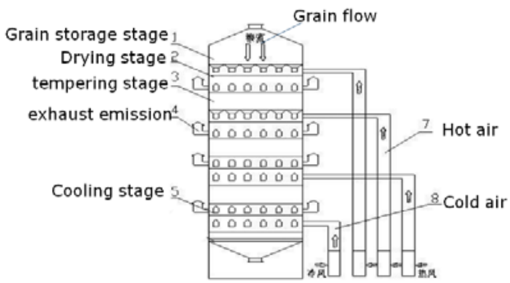


Fig.8. Schematic drawing of concurrent and counter current dryer.

The concurrent and counter current dryer (Fig.7) was applied in Nenjiang to optimize the drying process. In the process, the hot air temperature in each drying stage was gradually reduced. When the hot air temperatures of the 1^{st}, 2^{nd} and 3^{rd} drying stages were reduced to 95℃, 75℃ and 60℃, respectively, the browning rate was reduced to 15%～16% (Table 5). Keeping the hot air temperature constant at each drying stage, by drying twice, the browning rate was reduced to 4%～6%.

Table 5. Browning rate (%) of MaizeKX7349 maize.

1st drying stage		2nd drying stage		3rd drying stage		Draining maize (Hz)	Browning rate (%)
Hot air (℃)	Grain (℃)	Hot air (℃)	Grain (℃)	Hot air (℃)	Grain (℃)		
120	40	100	52	70	45	10	25 ~ 30
110	30	95	50	70	43	9	22 ~ 28
100	30	80	40	70	41	8	17 ~ 20
95	26	75	37	60	45	7	15 ~ 16
95	24 25	75	35 40	60	42 43	15 16	(drying twice) 4 ~ 6

This can be explained by the fact that between the first and second drying stages, there was a sufficiently long tempering stage. During the long tempering stage, moisture transported from the interior of a kernel to the surface, and consequently, the water near the surface could be removed easily when subjected to drying conditions again. This not only reduced the drying time but also the energy consumption.

4. Discussion

Drying temperature, drying time and drying method were the main influence factors of the browning rate. Initial MC of maize hardly influenced browning. Increasing drying temperature and drying time led to an increase in the browning rate. The analysis showed drying temperature and time significantly affected the browning rate. This finding had important implications in optimization of the drying process.

Regarding the browning mechanism, the following new findings were concluded: 1. browning materials were mainly in maize pericarp and soluble in water, 2. the browning was induced by oxidation of the water-soluble materials, and 3. glucose content was higher in browning maize than in non-browning maize.maizemaizemaize

The concurrent and counter current dryer was applied in Nenjiang to optimize the drying process. The hot air temperature in each drying stage was gradually reduced. When the hot air temperatures of the 1st, 2nd and 3rd drying stages were reduced to 95℃, 75℃ and 60℃, respectively, the browning rate was reduced to 15% ~ 16%. Keeping the hot air temperature constant at each drying stage, by drying twice, the browning rate was reduced to 4% ~ 6%.

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