41

2015 ASBC Annual Meeting

Optimization of kilning conditions for multiparameter equilibrium of malt using response surface methodology

Shuxia Huang, Junhong Yu, Hua Yin, Jianjun Dong, Shumin Hu, Jia Liu

State Key Lab of Biological Fermentation Engineering of Beer, Tsingtao Brewery Co., Ltd., Qingdao, China

June14-17,2015
La Quinta Resort & Club
La Quinta, CA, USA

PURPOSE

The influence of kilning conditions on malt quality was investigated with Response Surface Methodology, during which ten kinds of parameters related to malt flavour stability, malty aroma and sensory evaluation were first comprehensively assessed. And the optimal kilning condition was obtained by carrying out the numerical optimization of kilning technology for balancing the content of the positive and negative parameters.

MALT SAMPLES

Gairdner barley from Australia was provided by Tsingtao Brewery Malt Factory (Shandong Province, China).

MICRO-MALTING TRIALS

Barley malt was micro-malted using an automated micro-malting machine (Joe White Malting Systems, Perth, Australia). Each aliquot of barley (500g) was weighted into the standard stainless steel container. The details of micro-malting process parameters before final kilning stage were shown at Table 1.

Table 1. Micro-malting process parameters

	Steeping	Germination	Withering
Process parameters	Wet8--dry10--wet7--dry8--wet7, 16°C	16°C, 96h, 100% fresh air, spraying at the 24h	45°C/1h--55°C/5h--65°C /5h--76°C/3h，50% re-used air at 76°C

SMALL-SCALE MASHING

Finely ground malt (40 g) was mixed with ultra-pure water (200 mL). The temperature was maintained at 50℃ for 40 min, and then increased to 65℃ at the rate of 1℃/min, maintained at 65℃ for 60 min, then increased to 73℃ at the rate of 1℃/min. The mash was cooled to room temperature and filtered with double filter paper. During the whole mashing, the liquor was being stirred and covered with special stainless lids for reducing the intake of large amount of oxygen. The wort was used for determining the parameters behind except for sensory taste evaluation which was made according to Congress Mash Method. The judging criteria tells the lower the sensory score, the better the wort.

EXPERIMENTAL DESIGN

A Box-Behnken factorial design with three factors and three levels, including three replicates at the centre points, was used for fitting a second-order response surface (Table 2). The response values were not shown here.

Table 2. Experimental design levels for response surface

Independent Variables	Coded Symbols	Level		
		-1	0	1
Kilning temperature (°C)	A	84	87	90
Kilning time (h)	B	2.5	3	3.5
Withering time (h)	C	10	12	14

STATISTICAL ANALYSIS AND RESPONSE SURFACE

Response value was subjected to a second–order multiple regression analysis using the least-squares regression methodology. F-test of LOX activity, nonenal potential, HDMF, TBZ, furural and methional showed that these model terms were highly significant to the experimental data (P-values were less than 0.05 and R-squared was more than 0.9). Response surface was made by the fitted quadratic polynomial equation, holding independent variables with one parameter at a constant value, and changing the other two variables (Fig.1-5).

Within the limited scope of kilning intense, LOX activity and nonenal potential had the tendency of decline, while HDMF, TBZ, furural and methional gradually increased. LOX enzyme was deactivated at thermal treatment from high temperature. Nonenal potential was intricately affected by Maillard reaction products which possessed oxidative and reductive ability simultaneously, and the melanoidins produced by heat promoted or inhibited its information. HDMF, an important malty aroma, generated more at high temperature, because primary Maillard reaction accelerated the enolization of Amadori compounds. Similarly, TBZ, furural and methional were all influenced by advanced Maillard reaction, which resulted in the synthesis or strecker degradation of more starch and protein decomposed products(such as reducing sugar, amino acid).

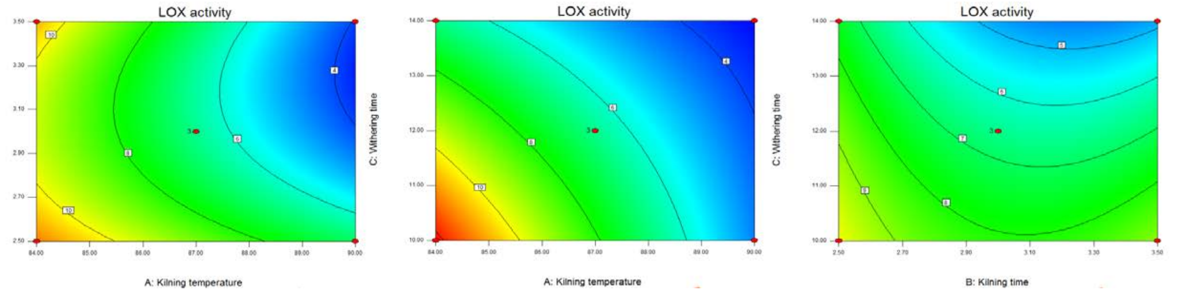

Fig.1 The influence of kilning condition on LOX activity

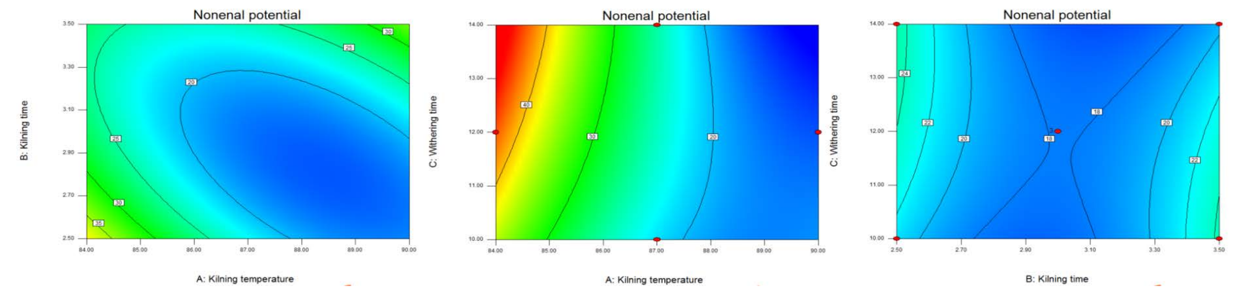

Fig.2 The influence of kilning condition on nonenal potential

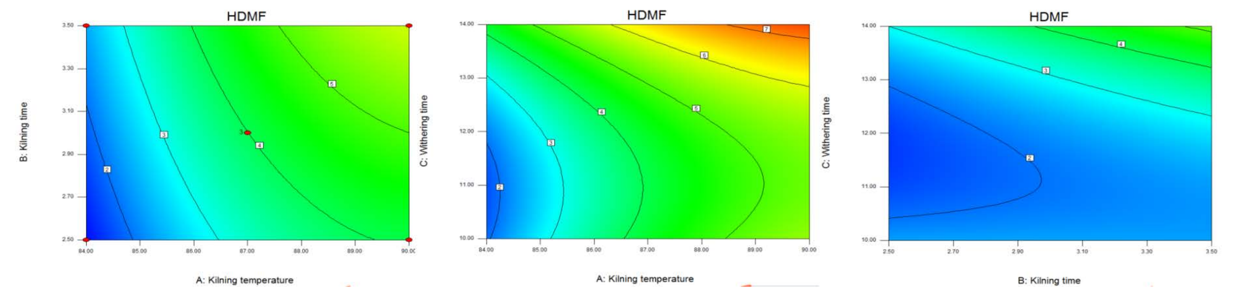

Fig.3 The influence of kilning condition on HDMF

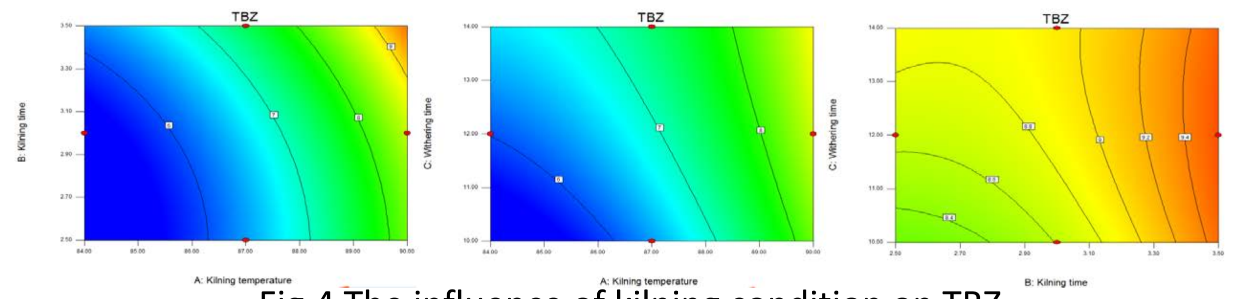

Fig.4 The influence of kilning condition on TBZ

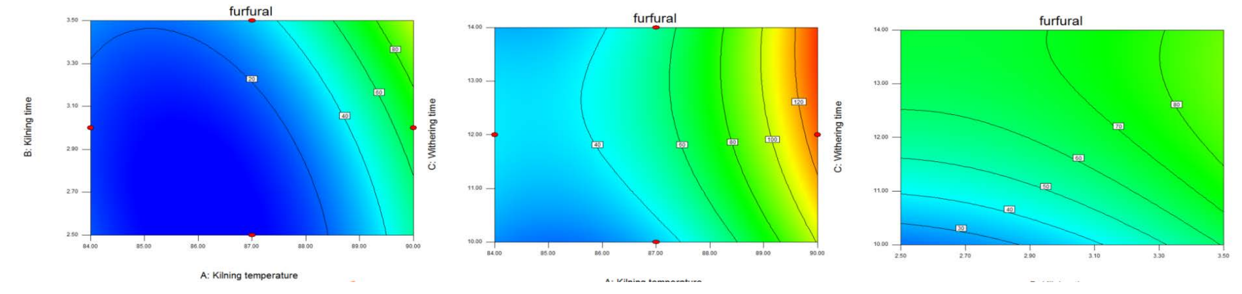

Fig.5 The influence of kilning condition on furfural

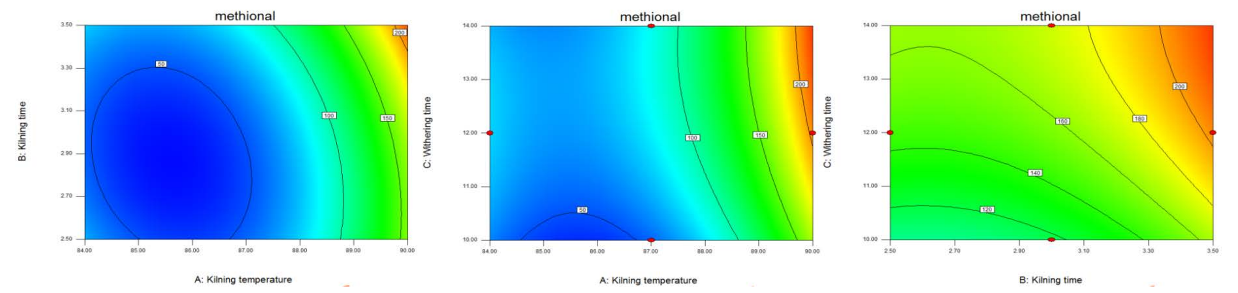

Fig.6 The influence of kilning condition on methional

OPTIMIZATION OF KILNING CONDITIONS AND EXPERIMENTAL VERIFICATION

Three kilning variables were optimized to balance the content of above positive and negative parameters. Subsequently, the selected solution was obtained: kilning temperature=86.35°C, kilning time=3.19 h, withering time=14.00 h. Then triplicate experiments were carried out and the mean values were in good agreements with the predicted values. Moreover, compared with the mean values of response parameters before being optimized, the rate of change showed that the value of positive parameters such as HDMF rose by about 37.6%, and the values of the other negative parameters obviously decreased.

Table 3. Comparison of predicted value, verification value and original response

Dependent variables	Predicted value	Mean value of verification experiments	Mean value of original response	Rate of change
LOX activity (U/g)	4.91	5.05	7.4	-31.8%
Nonenal potential (μg/L)	18.73	18.46	23.6	-21.8
HDMF (mg/kg)	5.90	5.78	4.2	37.6
Sensory score	2.52	2.47	2.6	-5.0
TBZ (EBC)	7.25	7.24	7.4	-2.2
Hexanal (μg/L)	4.08	3.38	9.7	-65.2
Furfural (μg/L)	36.00	36.36	51.3	-29.1
Methional (μg/L)	48.24	51.18	81.2	-37.0
Phenyl Acetaldehyde (μg/L)	57.53	59.26	66.8	-11.3
T-2-nonenal (μg/L)	1.20	1.18	2.0	-41.0

CONCLUSIONS

The influence of kilning technology were firstly studied on ten kinds of parameters related to stale flavor stability, malty aroma, sensory evaluation with response surface methodology. LOX activity, nonenal potential and sensory score had the tendency of decline, while HDMF, TBZ and stale aldehydes obviously increased with the improvement of kilning intense. Variance analysis indicated that the second-order prediction models of LOX activity, nonenal potential, HDMF, TBZ, methional, furfural were highly significant. Subsequently, the optimization of kilning technology was carried out for balancing these positive and negative parameters and the optimum kilning condition was obtained. The optimum kilning temperature, kilning time and withering time were 86.35°C, 3.19 h and 14.00 h respectively. The mean value of three verification experiments coincided with the predicted value. Compared with the mean value of original response before being optimized, the value of ten parameters was obviously optimized from 2.2% to 65.2%. However, this method was not suitable for special malt, which need further study to meet its demand.

ACKNOWLEDGMENTS

We gratefully acknowledge the financial support from the National High Technology Research and Development Program of China (863 Program, grant no. 2013AA102109) and Qingdao city program (no. 14-2-3-49-NSH).

CONTACT US

Shuxia Huang, State Key Laboratory of Biological Fermentation Engineering of Beer, Tsingtao brewery Co.,Ltd
602 Tailiu Road, Qingdao, China

Tel: 86-532-88891330
Email:
huangsx@tsingtao.com.cn