Toxicology and Environmental Health 1994, 41(1): 1-52.

[3] Verrier J L, Wiernik A, Staaf M, Cadilhac J L, Onillon M, Vidal B. The influence of post-curing of burley tobacco and dark air-cured tobacco on TSNA and nitrite levels. 2008 CORESTA Congress, 2008, Shanghai.

[4] 史宏志 , 李进平 , Bush L P, 李宗平 , 王昌军 , 张祥林 . 白肋烟杂交种及亲本烟碱转化株的鉴别 [J]. 中国烟草学报 , 2005（4）: 28-32.
SHI Hongzhi, LI Jinping, L P Bush, LI Zongping, WANG Changjun, ZHANG Xianglin. Identification of nicotine converters in Chinese burley hybrids and parents[J]. Acta Tabacaria Sinica, 2005(4): 28-32.

[5] M V Djordjveic, S L Gay, L P Bush and J F Chaplin. Tobacco-spe -cific nitrosamines accumulation and distribution in flue-cured tobacco iso –lines[J]. J Agric Food Chem, 1989; 37: 751-756.

[6] Andersen R A , Fleming P D , Burton H R. N ′-Acyl-and N ′nitroso -pyridine alkaloids in alkaloids lines of burley tobacco during growth and air–curing[J]. J Agric Food Chem, 1989; 37: 44-50.

[7] Hetch S S, Chen C B, Hirota N. Tobacco-specific nitrosamines: Formation from nicotine in vitro and during curing and carcinogenicity in strain amice[J]. J Natl Cancer Inst, 1978; 60: 819-824.

[8] Caldwell W S, Grenn J M , Plowchalk D R. The nitrosation of nicotine : A kinetic study[J]. Chem Res Tox, 1991; 4: 513-516.

[9] W J Chamberlain, J L Bake, O T Chortyk. Studies on the redution of nitrosamines in tobacco[J]. Tobacco Science, 1986; (30): 81-82.

[10] Fischer S, Spiegelhalder B, Preussmann R. Performed Tobacco-specific nitrosamines in tobacco role nitrate and influence of tobacco type[J]. Carcinogenesis, 1989, (10)8: 1511-1517.

[11] 孙楹淑 , 王瑞云 , 史宏志 , 等 . 氧化剂和抗氧化剂处理对高温贮藏白肋烟 TSNAs 形成的影响 [J]. 烟草科技 , 2015, 04: 19-22, 31.
SUN Wenshu, WANG Ruiyun, SHI Hongzhi, et al. Effects of Oxidants and Antioxidants on TSNAs Formation in Burley Tobacco Stored at High Temperature[J]. Tobacco Science & Technology, 2015,04:19-22,31.

[12] 王瑞云 , 史宏志 , 等 . 烟草贮藏过程中 TSNAs 含量变化及对高温处理的响应 [J]. 中国烟草学报 , 2014(1): 48-53.
WANG Ruiyun, SHI Hongzhi, et al. Changes in TSNAs contents during tobacco storage and its response to high temperature treatment[J]. Acta Tabacaria Sinica, 2014(01):48-53.

[13] 孙楹淑 , 杨军杰 , 史宏志 , 等 . 不同氮素形态对烟草硝态氮含量和 TSNA 形成的影响 [J]. 中国烟草学报 , 2015, 21(4): 78-84.
SUN Wenshu, YANG Junjie, SHI Hongzhi, et al. Effect of different nitrogen forms on nitrate nitrogen conlent and TSNAs formation jn tobacco[J]. Acta Tabacaria Sinica, 2015, 21(4): 78-84.

[14] Saito H, Miyazaki M, Miki J (2006). Role of nitrogen oxides in tobacco-specific nitrosamine formation in burley tobacco. 2006 CORESTA Congress. AP 17, Paris,France. https://www.coresta.org/abstracts/role-nitrogen-oxides-tobacco-specific-nitrosamine -formation-burley-tobacco-2254.html.

[15] SHI H Z, WANG R Y, BUSH L P, et al. Changes in TSNA contents during tobacco storage and the effect of temperature and nitrate level on TSNA formation[J]. Journal of Agricultural and Food Chemistry, 2013, 61(47): 11588-11594.

[16] Jack A, Bush L. (2007) The “LC” protocol. http://www.uky.edu /Ag/Tobacco/Pdf/ LC-Protocol. Pdf . Accessed 3 March 2007.

[17] 戴亚 , 方力 , 陆登梯 , 刘启斌 , 宣晓泉 . 分光光度法测定烟草中的硝酸盐 [J]. 中国烟草科学 , 2000, 02: 33-35.
DAI Ya, FANG Li, LU Dengti, LIU Qibing, XUAN Xiaoquan, Determination of nitrate in tobacco by spectrophotometer[J]. Chinese Tobacco Science, 2000, 02: 33-35.

[18] ZHOU Jun, BAI Ruoshi, ZHU Yongfa. Determination of four tobacco-specific nitrosamines in mainstream cigarette smoke by gas chromatography/ion trap mass spectrometry[J]. Rapid Communications in Mass Spectrometry, 2007, 21(24): 4086-4092.

[19] 王瑞云 . 烟草贮藏过程中 TSNA 形成及与温度和硝酸盐含量的关系 [D]. 河南农业大学 ,2014.
WANG Ruiyun. Formation of TSNA during tobacco storage and the relationship with temperature and nitrate contents[D]. Henan Agricultural University, 2014.

[20] 余义文 , 夏岩石 , 李荣华 , 等 . 不同类型及品种烟草特有亚硝胺含量的分析 [J]. 烟草科技 , 2013(4): 46-51, 55.
YU Yiwen, XIA Yanshi, LI Ronghua, et al. Analysis of TSNA Contents in Tobacco Leaves of Different Types and Cultivars[J]. Tobacco Science & Technology, 2013(4): 46-51, 55.

[21] 孙楹淑 , 王俊 , 史宏志 , 等 . 硝态氮含量对烟叶高温贮藏过程中 TSNA 形成的影响 [J]. 中国烟草学报 , 2015, 21(2): 53-58.
SUN Wenshu, WANG Jun, SHI Hongzhi, et al. Effect of nitrate nitrogen level in tobacco leaves on TSNAs formation during high temperature storage[J]. Acta Tabacaria Sinica, 2015, 21(2): 53-58.

TSNAs contents in lamina and midrib of flue-cured tobacco and their changes after high temperature storage

JIN Tong[1]，SHI Hongzhi[1*]，ZHOU Jun[2]，BAI Ruoshi[2]，YANG Huijuan[1], ZHAO Shimin[3]，WANG Jun[1]

1 Tobacco Cultivation Key Laboratory of Tobacco Industry/Tobacco Harm Reduction Research Center, Henan Agricultural University, Zhengzhou 450002, China;

2 Beijing Cigarette Factory, Beijing 100024, China；

3 Henan Luoyang Tobacco Company, Luoyang 471000, Henan, China

Abstract: Thirty flue-cured tobacco samples from Henan, Yunnan, Guizhou, Hunan and Guangdong were collected and a variety test was set up in Luoyang, Henan province to investigate the relationship between TSNAs content and their precursors in flue-cured tobacco lamina and midrib, and effect of geographic location, variety and leaf position on this relationship. Flue-cured tobacco lamina and midrib were stored at 50℃ to study the effect of high temperature storage on contents of TSNAs, alkaloid and nitrate. Results showed that content of TSNAs in flue-cured tobacco lamina was significantly higher than in midrib, and the highest proportion in lamina was NNN, whereas the highest percentage in midrib was NNK. Total alkaloids in lamina were about 4.7 times higher than in midrib. Nitrate content in midrib was higher than in lamina. TSNAs content in lamina varies significantly between regions, with the highest content in Hunan and Guangdong. Significant differences were found in TSNAs content of lamina between varieties, and the changes of TSNAs were closely related with alkaloid content. Lamina had the highest TSNAs content, followed by side-vein and mid-vein. Correlation analysis revealed that accumulation of TSNAs in tobacco was mainly affected by amount of alkaloid accumulated during flue-curing. TSNAs content of midrib and lamina under 50℃ storage increased 229.2% and 30.6%, respectively, compared with that in low temperature, suggesting that nitrate levels had greater influence on TSNAs formation during high temperature storage.

Keyword: flue-cured tobacco; TSNAs; midrib; lamina; nitrate; high temperature storage

Citation： JIN Tong，SHI Hongzhi，ZHOU Jun, et al. TSNAs contents in lamina and midrib of flue-cured tobacco and their changes after high temperature storage [J]. Acta Tabacaria Sinica, 2017, 23(2)

***Corresponding author.** Email：shihongzhi88@163.com

《烟草科技》2017 年第 3 期目次