CHEMICAL ENGINEERING TRANSACTIONS
VOL. 62, 2017

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Fei Song, Haibo Wang, Fang He

ISBN 978-88-95608- 60-0; **ISSN** 2283-9216

DOI: 10.3303/CET1762071

The Impact of Geographical Location on the Characteristics and Chemical Components of Zanthoxyhum Bungeanum Seed

Zhongjiang Feng[a,b], Luxia Xing[a]

[a]College of Resource and Environment Science, Hebei Normal University, Shijiazhuang 050024, China
[b]Hebei Key Laboratory of Environmental Change and Ecological Construction, Shijiazhuang 050024, China
fengzhongjiang@163.com

The Zanthoxyhum bungeanum seeds from 8 provinces in China were analyzed to show the impact of geographical location on their characteristics and chemical components. Thus, the analysis can serve as theoretical basis for cultivating high-quality Zanthoxyhum bungeanum and improving its economic benefit. The experimental result showed the average transverse diameter of the seed was 3.84mm, the average vertical diameter was 3.05mm and the shape index was 1.19-1.32, thus indicating that the geographical location had no significant impact on the shape of Zanthoxyhum bungeanum. Besides, the oil ratio of Zanthoxyhum bungeanum seeds from 9 provenances is 25%-31.5%. Among them, the ratio of Shanxi, reaching 31.5%, was much higher than those of Henan, Hebei and Inner Mongolia. The overall unsaturated fatty acid of the seed was 60%-79.5%. Thus, the oil ratio was significantly impacted by altitude, rainfall and annual aridity index. Furthermore, the 1000-seed weight of eastern plain is relatively heavier than that of western plateau while the peel ratio of western plateau is higher than that of eastern plain. Hence, the weight and peel ratio were both greatly influenced by geographical location.

1. Introduction

Zanthoxyhum bungeanum (Z. bungeanum), is a native crop grown in most provinces in China at an altitude of 200-2500m, however, it is mostly produced by provinces in Northwest and Southwest China. Z. bungeanum, 2-7m tall, has brownish black trunk with prickle and leaves with opposite phyllotaxis. When its fruit is mature, it turns to be bright red, and has a numb smell. The main breed in China is Dahongao, Qinan (I) and green Zanthoxyhum bungeanum, ect.

Zanthoxyhum bungeanum is a high-quality cash crop, because it is undemanding for the growing environment, and has good cold resistance. It is not only used as condiments, biodiesel and other raw materials, but also medicines killing insects, relieving pains, dispelling the cold, and eliminating dampness (Xiong et al., 1997; Bowers et al., 1993; Artaria et al., 2011; Li et al., 2009; Yang et al., 2008; Rasheed et al., 2013; Dossou et al., 2013; Zhao et al., 2013; Guo, 2017; Busato et al., 2017; Tarantino et al., 2017; Ghazouani et al., 2017; Licata et al., 2017; Kornecki and Prior, 2017; Werle et al., 2017; Tao et al., 2017; Zeng et al., 2017; Fu et al., 2017; Le et al., 2017; Zhang et al., 2017).

With the increasing demand of China and its neighboring countries for Zanthoxyhum bungeanum Maxim, the research on its cultivation, growing environment, pest prevention and cure and medicinal use has also been deepened (Hussain et al., 2000; Xia et al., 2011; Zhang and Jiang, 2008; Tezuka et al., 2001). However, the research on the ecological and chemical difference on variable geographical location is rare. Factors affecting the genetic diversity of Zanthoxyhum bungeanum Maxim are breeding system, gene flow, genetic drift and natural selection. Furthermore, the ability to resist drought and cold differs from various geographical locations and climates.

The Zanthoxyhum bungeanum seeds from 8 provinces in China were analyzed to show the impact of geographical location on their features and chemical components. Therefore, the analysis can serve as theoretical basis for cultivating high-quality Zanthoxyhum bungeanum and improving its economic benefit.

Please cite this article as: Zhongjiang Feng, Luxia Xing, 2017, The impact of geographical location on the characteristics and chemical components of zanthoxyhum bungeanum seed, Chemical Engineering Transactions, 62, 421-426 DOI:10.3303/CET1762071

2. Experimental samples and methods

Experimental samples are Dahongpao Z. bungeanum produced in Inner Mongolia, Qinghai, Gansu, Ningxia, Shanxi, Shaanxi, Shandong, Henan and Hebei. 20 well- grown and pest-free samples were chosen to be studied from each province. Table 1 shows relevant parameters of each province (altitude, longitude, latitude, annual rainfall, mean annual temperature).

Table 1: Climatic and Geographical Factors of Different Origins of Zanthoxyhum Bungeanum

Site	Altitude/m	Longitude /(°)	Latitude /(°)	Annual rainfall/mm
Nei Menggu	100	123.50	48.47	213.5
Qinghai	180	105.4	34.6	255.3
Gansu	140	102.8	35.1	505.5
Ningxia	112	107.41	37.78	300.6
Shanxi	915	109.2	35.4	597.2
Shanxi	980	104.7	32.5	622.2
Shandong	850	109.4	35.5	699.3
Henan	790	107.3	34.6	811.5
Hebei	850	115.6	37.8	551.4
Site	Annual aridity index	Mean annual temperature/°C	Annual sunshine percentage/%	Annual aridity index
Nei Menggu	2.7	6.0	63	2.7
Qinghai	2.4	9.8	59	2.4
Gansu	1.3	10.5	54	1.3
Ningxia	1.5	8.4	55	1.5
Shanxi	1.1	9.3	57	1.1
Shanxi	0.9	12.3	58	0.9
Shandong	1.2	12.7	52	1.2
Henan	1.4	16.2	52	1.4
Hebei	1.6	13.2	61	1.6

The seed and peel were collected by drying the sample in the sun to test the seed-shape index, weight of 1000 seeds and oil ratio. The seed-shape index was tested by knowing the ratio of transverse and vertical diameter with vernier caliper. The 1000-seed weight was obtained by figuring out the average value of ten 100-seed weights, and then the peel ratio can be calculated. Oil ratio, fatty acid and other parameters were tested with special experimental instruments, and data were collected and analyzed with SPSS.

3. The experimental result and analysis

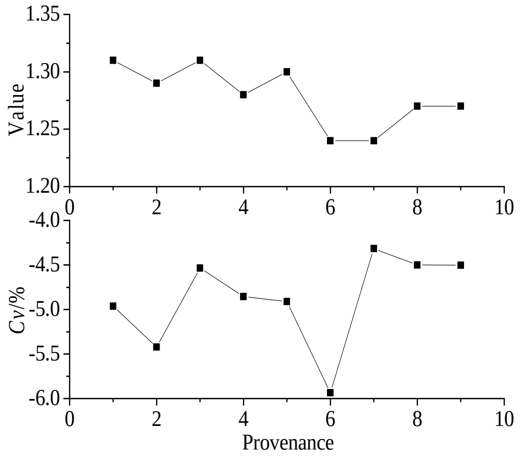
3.1 Characteristics of Zanthoxyhum bungeanum seeds from different provenances

Figure 1(a) compares the seed-shape index and coefficient of variation of Zanthoxyhum bungeanum produced in 9 provinces. The abscissa 1-9 respectively represents Zanthoxyhum bungeanum from Inner Mongolia, Qinghai, Gansu, Ningxia, Shanxi, Shaanxi, Shandong, Henan, and Hebei, and the expression of coefficient of variation is as follows:

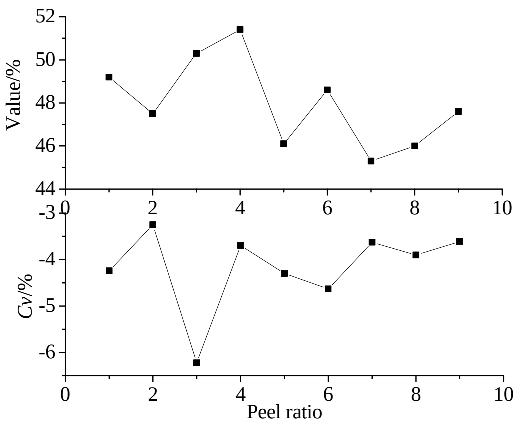
$$Cv = \left(sd / m\right) \times 100\% \quad (1)$$

Sd and M respectively stands for standard deviation and average value. As shown in the figure, the transverse diameter of the seed produced in Gansu and Ningxia province is shorter than those of other provinces while the vertical diameter from Shanxi is longer than those of other provinces. The seed shape from different origins almost remained unchanged, therefore, the geographical location has no significant impact on the shape of Zanthoxyhum bungeanum.

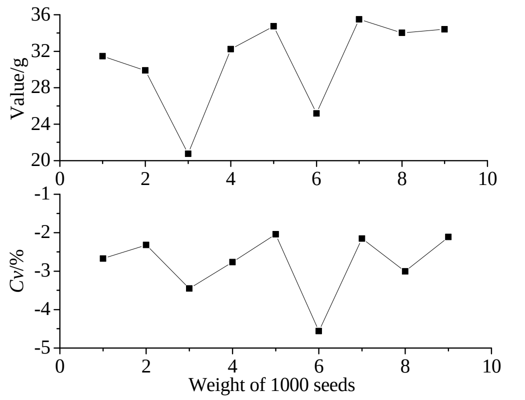
Figure 1(b) shows the 1000-seed weight of the 9 provinces. It can be seen from the figure that heavier seeds stored more nutrients, which promoted germinating rate. It is revealed that Shandong and Heibei had the heaviest seeds which were around 15% higher than the average value. Meanwhile, the seed weight of Gansu and Ningxia was 30% lower than the average.1000-seed weight of the western plateau is heavier than that of the western plain. Hence, the seed weight is significantly impacted by geographical location, and is positively correlated with the longitude.



(a) Seed-shape index



(b) Weight of 1000 seeds



(c) Peel ratio

Figure 1: Germination and Seeding Height of 3 Plants under Different Copper Concentration 3.2 The impact of geographical location on the chemical components

Figure 1 (c) presents the peel ratio curves of 9 origins. The provenance with higher peel ratio had thicker peel, which meant better yield. It is observed from the figure that the peel ratios of Shaanxi, Ningxia and Gansu were about 7-10% higher than the average value while those of Shandong, Henan, Hebei were lower than the average. This indicated that the western plateau had an overall higher peel ratio than the eastern plain, which demonstrated the peel ratio was also affected by geographical location.
Table 2 demonstrates the correlation between 1000-seed weight, seed-shape index, peel ratio and oil ratio and geographical location as well as meteorological environment. As the table reveals, the climate has great impact on the peel ratio. The June-August precipitation was negatively correlated with the ratio. This disclosed the more rainfall in summer caused insufficient sunshine for Zanthoxyhum bungeanum, thus impeding the growth of seed peel. However, the ratio and the sunshine percentage were positively correlated, meaning the provenance with more sunshine had higher peel ratio.

Table 2: Correlation between Seed Characteristics and Chemical Components and Geographical Locations of Z. bungeanum

Trait	Altitude	Longitude	Latitude	April-June precipitation
Weight of 1000 seeds	-0.0353	0.4618	0.2987	0.8256
Weight of 1000 peels	-0.4766	-0.2437	0.8643	0.8873
Seed index	0.0354	-0.1835	0.1249	-0.1265
Peel ratio	-0.7632	0.1267	0.5417	0.4712
Oil ratio	0.6471	-0.2694	0.2235	0.6753
Trait	**June-August precipitation**	**Annual aridity index**	**Mean annual temperature**	**Annual sunshine percentage**
Weight of 1000 seeds	-0.7634	-0.4325	0.7335	0.0257
Weight of 1000 peels	-0.9178	0.7221	0.6987	0.3995
Seed index	0.0796	0.1546	0.2479	0.2046
Peel ratio	-0.8345	0.4235	-0.1368	0.5137
Oil ratio	-0.3167	0.6723	-0.3698	-0.2282

Figure 2 presents the content of 6 fatty acids containing in the seed (oleic acid, linoleic acid, linolenic acid, palmitic acid, palmitoleic acid and unsaturated fatty acids). It can be observed in table 2 and figure 2 that the oil ratio of 9 provinces was 25%-30%. Shaanxi had the highest ratio of 31.5%, which was much higher than those of Henan, Hebei and Inner Mongolia. Hence, the oil ratio was greatly hinged on the altitude, precipitation and annual aridity index. At a higher altitude, the provenance with more April-June precipitation had higher oil ratio while that with more June-August precipitation had a lower oil ratio. The reason mainly lied in the fact that insufficient aridity index hindered seed maturation.
It is also can be seen from figure 2 that the content of oleic acid in the seed was the highest. Its average content in the 9 places reached 32%. The second highest was the linoleic acid with the average content of 20%. The seed from Shandong had the highest content of oleic acid while that of Shaanxi and Henan had a lower content. The overall content of unsaturated fatty acid was 60%-79.5% and the content differed from various provinces.

4. Conclusion

The Zanthoxyhum bungeanum seeds from 8 provinces in China were analyzed to show the impact of geographical location on their characteristics and chemical components. Thus, the analysis can serve as theoretical basis for cultivating high-quality Zanthoxyhum bungeanum and improving its economic benefit. The conclusion is as follows:
(1) The average transverse diameter of the seed was 3.84mm, the average vertical diameter was 3.05mm and the shape index was 1.19-1.32, thus indicating that the geographical location had no significant impact on the shape of Zanthoxyhum bungeanum.

(2) The oil ratio of Zanthoxyhum bungeanum seeds from 9 provenances is 25%-31.5%. Among them, the ratio of Shanxi, reaching 31.5%, was much higher than those of Henan, Hebei and Inner Mongolia. The overall unsaturated fatty acid of the seed was 60%-79.5%. Thus, the oil ratio was significantly impacted by altitude, rainfall and annual aridity index.
(3) The 1000-seed weight of eastern plain is relatively heavier than that of western plateau while the peel ratio of western plateau is higher than that of eastern plain. Hence, the weight and peel ratio were both greatly influenced by geographical location.

Acknowledgments

Fund Project: Hebei soft science research project. Research on the Spatial impact range of multi tier Core-periphery city in Beijing-Tianjin-Hebei (Topic number: 15457630D)

Reference

Artaria C., Maramaldi G., Bonfigli A., Rigano L., Appendino G., 2011, Lifting properties of the alkamide fraction from the fruit husks of zanthoxylum bungeanum, International Journal of Cosmetic Science, 33(4), 328-33, DOI: 10.1111/j.1468-2494.2010.00629.x

Bowers W.S., Ortego F., You X., Evans P.H., 1993, Insect repellents from the chinese prickly ash zanthoxylum bungeanum, Journal of Natural Products, 56(6), 935-938, DOI: 10.1021/np50096a019

Busato P., Sopegno A., Berruto R., 2017, Web-based tool approach for energy balance estimation designed for multiple-crops production systems, Chemical Engineering Transactions, 58, 289-294, DOI: 10.3303/CET1758049

Dossou K.S., Devkota K.P., Morton C., Egan J.M., Lu G., Beutler J.A., 2013, Identification of cb1/cb2 ligands from zanthoxylum bungeanum, Journal of Natural Products, 76(11), 2060-4, DOI: 10.1021/np400478c

Fu L., Shi S.Y., Chen X.Q., 2017, Accurate quantification of toxic elements in medicine food homologous plants using ICP-MS/MS, Food Chemistry, 245(15), 692-697, DOI: 10.1016/j.foodchem.2017.10.136.

Ghazouani H., Capodici F., Ciraolo G., Maltese A., Rallo G., Provenzano G., 2017, Potential of thermal images and simulation models to assess water and salt stress: application to potato crop in central tunisia, Chemical Engineering Transactions, 58, 709-714, DOI: 10.3303/CET1758119

Guo H.L., 2017, Environmental chemistry study on spatial variability of heavy metal in crops in funiu mountain area, Chemical Engineering Transactions, 59, 889-894, DOI: 10.3303/CET1759149

Hussain, Stephen S.O., Garrett S., 2000, Removal of feedback inhibition of delta (1)-pyrroline-5-carboxylate synthetase results in increased proline accumulation and protection of plants from osmotic stress, Plant Physiology, 122(4), 1129-36, DOI: 10.1104/pp.122.4.1129

Kornecki T., Prior S., 2017, Equipment development to manage cover crops for small and urban no-till farming systems, Chemical Engineering Transactions, 58, 181-186, DOI: 10.3303/CET1758031

Lee H.J., Koo H.J., Lee J., Lee S.C.., 2017, Authentication of Zanthoxylum Species Based on Integrated Analysis of Complete Chloroplast Genome Sequences and Metabolite Profiles, Journal of Agricultural and Food Chemistry, 65(47), 10350-10359, DOI: 10.1021/acs.jafc.7b04167.

Li H.Y., Pan K.W., Liu Q., Wang J.C., 2009, Effect of enhanced ultraviolet-b on allelopathic potential of zanthoxylum bungeanum, Scientia Horticulturae, 119(3), 310-314, DOI: 10.1016/j.scienta.2008.08.010

Li P., Zhou L., Mou Y., Mao Z., 2015, Extraction optimization of polysaccharide from zanthoxylum bungeanum using rsm and its antioxidant activity, International Journal of Biological Macromolecules, 72(73), 19, DOI: 10.1016/j.ijbiomac.2014.07.057

Licata M., La Bella S., Leto C., Bonsangue G., Gennaro M.C., Tuttolomondo T., 2017, Agronomic evaluation of ethiopian mustard (brassica carinata a. braun) germplasm and physical-energy characterization of crop residues in a semi-arid area of sicily (italy), Chemical Engineering Transactions, 58, 535-540, DOI: 10.3303/CET1758090

Rasheed A., Mahmood T., Gul-Kazi A., Mujeeb-Kazi A., 2013, A novel drug candidate for alzheimer's disease treatment: gx-50 derived from zanthoxylum bungeanum, Journal of Alzheimers Disease, 34(1), 203-13.

Tao X., Peng W., Xie D., Zhao C., Wu C., 2017, Quality evaluation of Hanyuan Zanthoxylum bungeanum Maxim. Using computer vision system combined with artificial neural network: A novel method, International Journal of Food Properties, 20(12), 3056-3063, DOI: 10.1080/10942912.2016.1271808.

Tarantino E., Disciglio G., Gatta G., Libutti A., Frabboni L., Gagliardi A., Tarantino A., 2017, Agro-industrial treated wastewater reuse for crop irrigation: implication in soil fertility, Chemical Engineering Transactions, 58, 679-684, DOI: 10.3303/CET1758114

Tezuka Y., Irikawa S., Kaneko T., Banskota A.H., Nagaoka T., Xiong Q., 2001, Screening of chinese herbal drug extracts for inhibitory activity on nitric oxide production and identification of an active compound of zanthoxylum bungeanum, Journal of Ethnopharmacology, 77(2), 209-217, DOI: 10.1016/s0378-8741(01)00300-2

Werle S., Ziółkowski Ł., Bisorca D., Pogrzeba M., Krzyżak J., Milandru A., 2017, Fixed-bed gasification process-thecase of the heavy metal contaminated energy crops, Chemical Engineering Transactions, 61, 1393-1398, DOI: 10.3303/CET1761230

Xia L., You J., Li G., Sun Z., Suo Y., 2011, Compositional and antioxidant activity analysis of zanthoxylum bungeanum seed oil obtained by supercritical co_2 fluid extraction, Journal of the American Oil Chemists Society, 88(1), 23-32, DOI: 10.1007/s11746-010-1644-4

Xiong Q., Shi D., Yamamoto H., Mizuno M., 1997, Alkylamides from pericarps of zanthoxylum bungeanum, Phytochemistry, 46(46), 1123-1126, DOI: 10.1016/s0031-9422(97)84398-1

Yang F.X., Su Y.Q., Li X.H., Zhang Q., Sun R.C., 2008, Studies on the preparation of biodiesel from zanthoxylum bungeanum maxim seed oil, Journal of Agricultural & Food Chemistry, 56(17), 7891-6, DOI: 10.1021/jf801364f

Yang X., 2008, Aroma constituents and alkylamides of red and green huajiao (zanthoxylum bungeanum and zanthoxylum schinifolium), Journal of Agricultural & Food Chemistry, 56(5), 1689-96, DOI: 10.1021/jf0728101

Zeng, M., Wang J., Zhang M., Chen J., He Z., Qin F., Xu Z., Cao D., Chen, J., 2017, Inhibitory effects of Sichuan pepper (Zanthoxylum bungeanum) and sanshoamide extract on heterocyclic amine formation in grilled ground beef patties, Food Chemistry, 239(15), 111-118, DOI: 10.1016/j.foodchem.2017.06.097.

Zhang J.H., Jiang L.F., 2008, Acid-catalyzed esterification of zanthoxylum bungeanum seed oil with high free fatty acids for biodiesel production, Bioresource Technology, 99(18), 89-95, DOI: 10.1016/j.biortech.2008.05.004

Zhang Y., He F., Li D., Wang D., 2017, Effects of high temperature steam treatment on microbial and phytochemical contents, antioxidant activities, chemical stability, and shelf life of oral liquid prepared from the leaves of Zanthoxylum bungeanum Maxim, Journal of Food Processing and Preservation, 41(5), e13180, DOI: 10.1111/jfpp.13180.

Zhang Y., Luo Z., Wang D., He F., Li D., 2014, Phytochemical profiles and antioxidant and antimicrobial activities of the leaves of zanthoxylum bungeanum, The Scientific World Journal, 5, 181072, DOI: 10.1155/2014/181072

Zhao Z.F., Zhu R.X., Zhong K., He Q., Luo A.M., Gao H., 2013, Characterization and comparison of the pungent components in commercial zanthoxylum bungeanum, oil and zanthoxylum schinifolium, oil, Journal of Food Science, 78(10), 1516-22.