Analysis of Polar Components in Potato Wide Vermicelli by GC-MS

Bin Yue*, Yijun Wen, Weidong Chen, Zhuoxin Yin, Jiarui Xing

1College of Geography and Environmental Engineering, Lanzhou City University, Lanzhou City, Gansu, 730070, China
2Pollution Source Control Center of Jingchang City, Gansu, China
3Xinjia Environmental Protection Engineering Co., Ltd of Gansu Province, Gansu, 730070, China
*Corresponding author’s e-mail: yuebing@lzcu.edu.cn

Abstract. In order to arouse the society's attention to the ecological environment and food safety, the traditional food with rich nutrition ---- vermicelli was regarded the research object. Gas chromatography-mass spectrometry (GC-MS) was used to analyze the polar components of potato wide vermicelli. The results showed that twenty more polar organic matters were detected in potato wide vermicelli, containing saturated fatty acids, unsaturated fatty acid and phthalate (PAEs). The content of unsaturated fatty acid on the surface of the wide vermicelli was higher than that on the inside. The phthalate only exists on the surface of the wide vermicelli. People should reduce the use of disposable plastic products to reduce the negative effects of plastics on human health and realize the healthy development of the human ecological environment.

1. Introduction
The ecological environment is the material basis for human survival and reproduction[1]. With the development of social economy, ecological environmental pollution has become one of the global crises. Pollutants enter the environment and cause pollution to the atmosphere, water bodies and soil. Contaminated products enter the human body through the food chain and cause irreversible harm to human health. Therefore, strengthening food quality and safety is the guarantee of people's health and the harmonious development of society[2].

Vermicelli is rich in carbohydrates, dietary fiber, protein, niacin and minerals. They are popular among the public due to their good taste and their own softness and smoothness [3]. However, food safety incidents occur frequently. The "toxic vermicelli" with excessive aluminum content in order to reduce production costs entered the market [4]. Therefore, it is necessary to strengthen the safety detection of vermicelli, which not only includes inorganic ingredients, but also strengthens the analysis and monitoring of organic ingredients. Especially, the detection of fatty acids in food has become a key work in the field of food detection [5]. Gas chromatography and mass spectrometry (GC-MS) combines the characteristics of chromatography and mass spectrometry. It provides rich compound structure information and greatly improves the qualitative analysis capabilities of components. It has many advantages such as high sensitivity, good selectivity, wide application range and high analysis efficiency [6-8]. It has become the preferred analysis method for organic pollutants in environmental monitoring laboratories at all levels [9]. In addition, it has been applied in the
detection of traditional Chinese medicine [10], water quality [11], pesticide residue [12], meat products, fruits and vegetables and other food flavors [13-15], petrochemical industry [16] and other fields [17]. In the study, GC-MC technology was used to compare and analyze the composition and content of surface and inside polar organic compounds in vermicelli, and to study the types and ways of organic pollutants introduced into vermicelli. It aims to provide scientific data for food safety supervision.

2. Samples and Methods

2.1. Samples Treatment

Potato wide vermicelli sample (100.0000g) purchased from market was weighed accurately and put into a 250 ml beaker, and then added appropriate amount of refined chloroform into the beaker containing the sample (subject to the sample just passing). Then the sample was extracted with CHCl₃ by ultrasonic for 3 times and each time for 20 minutes, and the three extracts were mixed. Finally, the organic substances extracted were weighted after CHCl₃ was completely volatilized. The wide vermicelli sample extracted by solvent was placed in an oven at 15 ℃-20 ℃. After the wide vermicelli was dried, it was pulverized and filtered with 80 mesh sieve. Potato wide vermicelli powder sample (50.0000g) was weighed accurately and put into a 250 ml beaker, and then added appropriate amount of refined chloroform into the beaker containing the sample (subject to the sample just passing). Then the sample was extracted with CHCl₃ by ultrasonic for 3 times and each time for 20 minutes, and the three extracts were mixed. Finally, the organic substances extracted were weighted after CHCl₃ was completely volatilized. The organic substances extracted were esterified with BF₃ in methanol to convert the carboxylic acid to its corresponding methyl ester, which increases the stability and were easy to analyze by gas chromatography [18]. The same volume of refined dichloromethane and refined methanol mixture (volume ratio: 1:1) was added to the above extracted samples to dissolve the organic matter, 5ml BF3/CH3OH reagent was added, and the mixture was shaken gently. Finally, the samples were sealed and stored in a 60 ℃ constant temperature water bath for 10h. The sample transferred to a 120ml separation funnel after methyl-esterification. Then 60 ml ultrapure water and 20 ml refined (C₂H₅)₂O were added to the separation funnel. The sample was shaken fully and left to rest. After stratification, the organic phase was retained. Then add another 40ml of ultra-pure water. The sample was shaken fully and left to rest. Finally, when the liquid level is stratified, the organic phase is transferred to the weighing bottle and weighed after the ethyl ether volatilizes.

2.2. Instruments and Sample Conditions

1-2 drops of refined dichloromethane solvent were slowly added along the wall of the weighing bottle and shaken gently after the ethyl ether was completely volatilized. Finally, the composition of polar fractions was analyzed by GC-MS [19, 20]. (GC6890 N/MSD5973 N) equipped with a J&W HP-5 column (30 m × 0.32 mm i.d. × 0.25-μm film thickness) and the carrier gas was helium (99.999%) at a rate of flow of 1.0 ml/min with 1 μL injection. The organic compounds in wide vermicelli samples were identified according to spectrum library with NIST05 L (U.S.A.), and the peak area was normalized to calculate the content of each component.

3. Results and discussion

3.1. Analysis of Organic Composition of Surface Extract of Wide Vermicelli

Mass chromatogram of fatty acid (methyl ester products) from the surface potato wide vermicelli was shown in Figure 1. Organic matters peaks appear from 10.919 min. 23 kinds of polar components were detected in the surface extract sample of wide vermicelli. The components and content were shown in Table 1.
Figure 1. Fatty acid mass chromatogram from sample of surface potato wide vermicelli.

Table 1. Identification table of fatty acid extract (methylated) in surface potato vermicelli.

| Peak number | Molecular formula | Molecular weight | Compound name | Content (%) |
|-------------|-------------------|------------------|---------------|-------------|
| 1           | C_{10}H_{10}O_{4}  | 194              | Dimethyl phthalate | 1.954       |
| 2           | C_{10}H_{10}O_{4}  | 194              | 1,4-Benzenedicarboxylic | 0.456       |
| 3           | C_{10}H_{10}O_{4}  | 194              | 1,3-Benzenedicarboxylic | 0.536       |
| 4           | C_{15}H_{30}O_{2}  | 242              | Methyl iso-tetradecanoate | 0.361       |
| 5           | C_{15}H_{30}O_{2}  | 242              | Methyl tetradecanoate | 1.587       |
| 6           | C_{15}H_{32}O_{2}  | 256              | Pentadecanoic acid, methyl ester | 0.216       |
| 7           | C_{15}H_{32}O_{2}  | 256              | Pentadecanoic acid, methyl ester | 0.713       |
| 8           | C_{15}H_{32}O_{2}  | 256              | Pentadecanoic acid, methyl ester | 3.062       |
| 9           | C_{15}H_{34}O_{2}  | 270              | iso-Hexadecanoic acid, methyl | 0.986       |
| 10          | C_{15}H_{32}O_{2}  | 268              | 9-Hexadecanoic acid, methyl ester | 1.907       |
| 11          | C_{16}H_{34}O_{2}  | 270              | Hexadecanoic acid, methyl ester | 64.435      |
| 12          | C_{16}H_{34}O_{2}  | 284              | Heptadecanoic acid, methyl ester | 0.430       |
| 13          | C_{16}H_{34}O_{2}  | 284              | Heptadecanoic acid, methyl ester | 0.332       |
| 14          | C_{16}H_{34}O_{2}  | 284              | Heptadecanoic acid, methyl ester | 0.921       |
| 15          | C_{16}H_{34}O_{2}  | 294              | 9, 12-Octadecadienoic acid, methyl | 2.219       |
| 16          | C_{16}H_{36}O_{2}  | 296              | 9-Octadecenoic acid, methyl ester | 0.941       |
| 17          | C_{16}H_{38}O_{2}  | 298              | Octadecanoic acid, methyl ester | 14.475      |
| 18          | C_{18}H_{40}O_{2}  | 312              | nonadecanoic acid, methyl ester | 0.523       |
| 19          | C_{20}H_{42}O_{2}  | 326              | Eicosanoic acid, methyl ester | 1.398       |
| 20          | C_{21}H_{44}O_{2}  | 352              | 13-Docosenoic acid, methyl ester | 0.844       |
| 21          | C_{22}H_{46}O_{2}  | 354              | Docosanoic acid, methyl ester | 0.615       |
| 22          | C_{23}H_{50}O_{2}  | 382              | Tetracosanoic acid, methyl ester | 0.649       |
| 23          | C_{24}H_{52}O_{2}  | 410              | Hexacosanoic acid, methyl ester | 0.440       |
3.2. Analysis of organic composition of inside extract of wide vermicelli

Mass chromatogram of fatty acid (methyl ester products) from the inside potato wide vermicelli was shown in Figure 2. Organic matter peaks appear from 14.750 min. 26 kinds of polar components were observed in the inside extract sample of wide vermicelli, The component and content were shown in Table 2.

![Figure 2. Fatty acid mass chromatogram from sample of inside potato wide vermicelli.](image)

| Peak number | Molecular formula | Molecular weight | Compound name | Content (%) |
|-------------|-------------------|------------------|---------------|-------------|
| 1 | C_{15}H_{30}O_{2} | 242 | Methyl tetradecanoate, methyl ester | 0.407 |
| 2 | C_{16}H_{32}O_{2} | 256 | Pentadecanoic acid, methyl ester | 1.267 |
| 3 | C_{17}H_{34}O_{2} | 270 | Hexadecanoic acid, methyl ester | 49.941 |
| 4 | C_{18}H_{36}O_{2} | 284 | Iso-Heptadecanoic acid, methyl ester | 0.282 |
| 5 | C_{18}H_{36}O_{2} | 284 | Heptadecanoic acid, methyl ester | 1.274 |
| 6 | C_{18}H_{36}O_{2} | 284 | Transiso-Heptadecanoic acid, methyl ester | 0.208 |
| 7 | C_{19}H_{36}O_{2} | 296 | 9-Octadecenoic acid, methyl ester | 0.717 |
| 8 | C_{19}H_{38}O_{2} | 298 | Octadecanoic acid, methyl ester | 16.380 |
| 9 | C_{20}H_{40}O_{2} | 312 | Nonadecanoic acid, methyl ester | 0.558 |
| 10 | C_{21}H_{42}O_{2} | 326 | 8,10-Dimethoxy-octadecanoic acid, methyl ester | 1.942 |
| 11 | C_{21}H_{40}O_{2} | 326 | Eicosanoic acid, methyl ester | 1.903 |
| 12 | C_{22}H_{44}O_{2} | 340 | Heneicosanoic acid, methyl ester | 0.330 |
| 13 | C_{23}H_{46}O_{2} | 354 | Docosanoic acid, methyl ester | 0.687 |
| 14 | C_{24}H_{48}O_{2} | 368 | Iso-Tricosanoic acid, methyl ester | 0.158 |
| 15 | C_{24}H_{50}O_{2} | 368 | Tricosanoic acid, methyl ester | 0.882 |
| 16 | C_{25}H_{52}O_{2} | 382 | Iso-Tetracosanoic acid, methyl ester | 0.912 |
| 17 | C_{25}H_{50}O_{2} | 382 | Tetracosanoic acid, methyl ester | 6.822 |
| 18 | C_{26}H_{52}O_{2} | 396 | Pentacosanoic acid, methyl ester | 1.478 |
It was found by comparison that the organic components and contents detected on the surface and inside of the wide vermicelli were not exactly the same, and the result was shown in Figure 3.

|    |     |                  |                  |        |
|----|-----|------------------|------------------|--------|
| 19 | C_{26}H_{52}O_{2} | 396              | Pentacosanoic acid, methyl ester | 2.260  |
| 20 | C_{27}H_{54}O_{2} | 410              | Iso-Hexacosanoic acid, methyl ester | 1.300  |
| 21 | C_{27}H_{54}O_{2} | 410              | Hexacosanoic acid, methyl ester   | 4.556  |
| 22 | C_{28}H_{56}O_{2} | 424              | Iso-Heptacosanoic acid, methyl ester | 0.200  |
| 23 | C_{28}H_{56}O_{2} | 424              | Heptacosanoic acid, methyl ester  | 0.373  |
| 24 | C_{29}H_{58}O_{2} | 438              | Octacosanoic acid, methyl ester   | 3.945  |
| 25 | C_{30}H_{60}O_{2} | 452              | Nonacosanoic acid, methyl ester   | 0.457  |
| 26 | C_{31}H_{62}O_{2} | 466              | Triacontanoic acid, octadecyl ester | 0.759  |

It can be seen from Figure 3 that fatty acids are present in wide flour, and the content of saturated fatty acids are much higher than that of unsaturated fatty acids. Fatty acid is an important component of food, and it is one of the main sources of energy in the body. It also is the basic component of cell membranes. It provides metabolic energy, affects receptors, and helps memory and cognition [21]. Different fatty acids have different biological properties and physiological activities. For example, oleic acid acts as a complex of membrane phospholipids at the cellular level, which can increase membrane fluidity and transport, and stimulate enzyme activity [20]. The amount of carbon in the components of saturated fatty acid (SFAs) in two samples is approximately the same, mainly composed of C_{14}-C_{26} (on the sample surface) and C_{14}-C_{30} (inside the sample). The content of even-carbon fatty acid was higher than that of odd-carbon fatty acid in most cases. This phenomenon is consistent with the variation trend of fatty acid content in biological samples. In biological systems, the content of even-carbon saturated fatty acid compounds are usually higher than the odd-carbon (the carbon number is between 12 and 24) [20, 22]. Unsaturated fatty acids are generally considered to have the effect of lowering bad cholesterol and preventing atherosclerosis [23, 24]. For example, linoleic acid has the reputation of "vascular scavenger", which can lower blood lipids, soften blood vessels, lower blood pressure, and promote microcirculation. It can prevent or reduce the incidence of cardiovascular disease [25]. Erucic acid is an ultra-long-chain unsaturated fatty acid, which consists of 22 carbon atoms and a cis double bond on C-13 [26, 27]. It is not easy to be hydrolyzed and digested by the human body, which is easy to cause the accumulation of cholesterol. It can also combine with phosphatidylcholine to cause heart fat deposition and endanger health [28]. The content of unsaturated fatty acids in the two samples were significantly different, inside content (0.72%) < surface content (4.00%). Linoleic acid and erucic acid were found only on the surface. Although oleic acid exists both on the surface and inside, it’s content in the inside (0.717%) is lower than that in the surface (0.941%). The content relationship of unsaturated fatty acids between on the surface and inside of the wide vermicelli indicated that the unsaturated fatty acids have been oxidized after the wide vermicelli was pulverized into powder. This is because the presence of unsaturated bonds causes unsaturated fatty acids to react to form trans-fatty acids during thermal processing [29]. In addition to saturated fatty
acids and unsaturated fatty acids, there are also phthalate esters (PAEs) on the surface of wide vermicelli, with a content of (2.95%).

Phthalates are the main body of plasticizers, which exist in agricultural films, plastic bags, toys and rubber pipes. They are continuously migrated and released into the atmosphere, soil and waters, which cause serious pollution to the environment. It can be absorbed into the human body through the respiratory tract, digestive tract and skin. Although most of it can be rapidly metabolized and decomposed and excreted through urine and faeces, a small amount may still accumulate in the human body [30]. Therefore, it harms human reproductive system, immune system and digestive system [31], and even causes gene poisoning and damages human genes [32]. There are three main possibilities for the appearance of plasticizer in wide vermicelli: one is that the raw material is polluted by the environment; the other is that it is produced during processing; the third is that it is polluted by plastic packaging [33]. According to the amount of plasticizer content relationship between on the surface and inside of the wide vermicelli, it can be inferred that the wide powder is more likely to be contaminated by plastic packaging. Therefore, the use of plasticizer products should be reduced as much as possible, so as to effectively stems the penetration of plasticizer and reduce its pollution to the human ecological environment.

4. Conclusions
The analysis of organic matter showed that the polar substances in wide vermicelli were more complex, including fatty acids and PAEs. Their composition and content are easily affected by the external environment. It is particularly important to strengthen the detection of plasticizers in food safety inspections.

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References
[1] Guo, J. (2019) Analysis on the protection of health rights damage under the background of environmental pollution. Blooming Season, 8:350–351.
[2] Kang, J. (2019) The influence of environmental pollution and food safety. Modern Agriculture, 11:33–34.
[3] Xue R.Q., Sun L.P., Liu J.C., Yang L. (2018) Uncertainty analysis of determination of residual aluminium in powder strips by ICP-MS. Grain Science and Technology and Economy, 43(12):55-57.
[4] National Health and Family Planning Commission. (2015) Chinalco limited adjustment and addition announcement of vermicelli (GB 2760-2016). Beijing.
[5] Li X.J., Zhao Z.H., Yang Y, Zhu H. (2016) Research progress on detection of fatty acids in food by gas chromatography. Journal of Food Safety & Quality, 8: 3114-3120.
[6] Grayson M.A. (2016) A history of gas chromatography-massspectrometry (GC/MS). Encyclopedia of Mass Spectrom, 9:152-158.
[7] Choi S.J., Jung M.Y. (2017) Simple and fast sample preparation followed by gas chromatography-tandem mass spectrometry (GCMS/MS) for the analysis of 2-and 4-methylimidazole in cola and dark beer. J Food Sci., 82(4):1044-1052.
[8] Geyer P.M., Hulme M.C., Irving J.P.B. (2016) Guilty by dissociation-development of gas chromatography-mass spectrometry (GC-MS) and other rapid screening methods for the analysis of 13 diphenidine-derived new psychoactive substances (NPSs). Anal Bioanal Chem., 408(29):8 467-8481.
[9] Zhang R.F. (2019) Discussion on the technical advantages of GC-MS in environmental monitoring. Super Science, 16:267-268.
[10] Wang T., Wu H.W., Guo R.X., Xu M.Y., Yu X.K. Tang L.Y. (2017) Influence of processing on volatile components in viticis fructus by GC-MS. Chinese Journal of Experimental Traditional Medical Formulae, 23(19):34-39.

[11] He B.Y., Kang L. (2015) Determination of propylene oxide in drinking water by gas chromatography-mass spectrometry. Chinese Journal of Health Laboratory Technology, 25(15):2472-2476.

[12] Xu R.R. (2017) Uncertainty evaluation of determination of chlorpyrifos in fruit juice by gas chromatography-tandem mass spectrometry. Journal of Food Safety & Quality, 8(7):2804-2809.

[13] Huang J.L., Yang G.X., Zhao Y.M. (2015) Detection method of chloropropanol in oil-rich foods by GC-MS. China Brewing, 34(8):143-146.

[14] Gui Q., Xuan X.F. (2016) Analysis of Aromatic Compounds and Fatty Acids Composition in Concentrated Coconut Milk by Centrifugation Using GC-MS. Chinese Journal of Tropical Agriculture, 36(4):77-81.

[15] Chen P., Zhu H.J., Wang J.G. (2016) Chemical constitution analysis of health care beverage of wood vinegar by gas chromatography-mass spectrometry. Food Research and Development, 37(15):183-185.

[16] Hu Z.M., Xiao L.Y., Shao H.Y., Jiang S.H., Zhao J. Q., Zheng K.W., Chen Z., Ren G.F. (2015) Target-screening of eight organic chloride compounds in chemical agents of liquid oil fields using gas chromatography and mass spectrometry. Journal of Shanghai University (Natural Science), 23(1):91-100.

[17] Xie J., He J.M. (2020) The application of gas chromatography-mass spectrometry (GC-MS) in the detection and analysis of volatile oil in plants. Journal of Shaoguan University, 41(6):61-65.

[18] Liu S., Wang A.W., Li M.Y., Yang L. (2014) Research progress of fatty acid methylation. China Pharmacy, 25(37):3535-3537.

[19] Chang G.H., Yue B., Li J., Yin Z.X., Gao T.P., Li X.K., Cheng Y.X. (2020) Analysis of polar components in salt by GC-MS. IOP Conference Series: Earth and Environmental Science, 568(1):012037.

[20] Chang G.H., Yue B., Gao T.P., Yan W.D., Pan G. (2020) 2020 Phytoremediation of phenol by Hydrilla verticillata (L.f.) Royle and associated effects on physiological parameters. J. Hazard. Mater., 388: 121569.

[21] Petrovic S., Arsic A. (2016) Fatty acids:Fatty acids. Encyclopedia of Food and Health, DOI:10.1016/B978-0-12-384947-2.00277-4.

[22] Zhao M., Wen X. (2016) ω-3 polyunsaturated fatty acids are beneficial or harmful for tumor treatment. Electron J Metab Nutr Cancer, 3(2):91-94.

[23] Sun Y.B. (2017) Research progress on detection of fatty acids component of food. Food Research And Development, 38(20):187-189.

[24] Guo X.J., Zhang D.H. (2020) Advance in conjugated linoleic acid esters derivatives. China Oils and Fats, 45(9):54-60.

[25] Vetter W., Darwisch V., Lehner K. 2020 Erucic acid in Brassicaceae and salmon- an evaluation of the new proposed limits of erucic acid in food. NFS Journal 19:9-15(2020).

[26] Wang J.J. (2018) Regulation of erucic acid content in Brassica carinata seeds. Wuhan: Hubei University.

[27] Xu G., Jiang J.F. (2006) Cooking oil and health of human body. Chinese Journal of Chemical Education, 27(7):1-3.

[28] Yao M.Y., Liang Q., Cui Y.Y., Huang W.Y., Zheng X.Y., Zhang W.M. (2020) Research progress on the formation mechanism of trans-fatty Acids from unsaturated fatty acids using oxidation pathway. Journal of the Chinese Cereals and Oils Association, 35(2):170-178.
[30] Li S. (2015) Analysis on the hidden dangers of edible salt. Technology Innovation, 9:195.
[31] Chen Y.M. (2019) The pollution rate and comparison of plasticizers in China from 1956 to 2017. Regional Governance, 34:69-71.
[32] Zhang J.W. (2014) Review of the research on the analysis methods of plasticizers in food. China Science and Technology Information, 8:77-79.
[33] Wang M.S. (2011) Toxicity of phthalate (plasticizer) and its harm to human health. Jiangsu Journal of Prev. Med., 22(4): 68-70.