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Application of Gas Chromatography Technology in the Determination of Flavor Components in the Food Industry

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Abstract

Meteorological chromatographic analysis is a method that uses helium or argon as carrier to inject mixture samples into chromatographic columns filled with fillers for separation. As a highly sensitive and efficient modern analysis technology, gas chromatography has been used in food analysis. However, due to its complicated operation, great attention should be paid to it when using. In this paper, the application of gas chromatography in the determination of flavor components in food industry was studied, and the nutritional value of soybean was evaluated scientifically and reasonably, and various nutrients and flavor components were quantitatively analyzed. The flavor components of 10 soybean protein isolate (SPI) samples were analyzed by headspace solid-phase microextraction and gas chromatography-mass spectrometry, so as to provide scientific basis for the breeding and processing of soybean flavor quality.

Keywords

Gas Chromatography; Food Industry; Soybean Protein Isolate; Flavor Components.

1. Introduction

China is the hometown of soybeans, and soybeans and soybean products have been one of the main foods of China people for thousands of years. The acquisition of food by human beings is not only a physiological demand for various nutrients and sanitary quality, but also a psychological enjoyment [1]. Food with good or unique flavor will make people feel really happy and directly affect their digestion and absorption of nutrients. The quality of soybean includes commodity quality, nutritional quality and flavor quality [2]. "Flavor" is one of the important indexes to evaluate the quality of vegetables, and the composition and content of flavor components are the key factors affecting the flavor quality of vegetables [3]. The analysis of soybean flavor components can not only evaluate the nutritional value of soybean scientifically and reasonably, but also provide scientific basis for flavor quality breeding and processing and utilization. SPI refers to protein with protein content above 90% and protein dispersion index between 80% and 90% [4]. Soybean is a vegetable that people eat all the year round because of its rich nutrition, fresh and palatable taste, various practices and storage resistance. According to incomplete statistics, the quality of soybean includes commodity quality, nutritional quality and flavor quality. Although there are many reports on soybean quality, the research on soybean quality at present focuses on nutritional quality and commodity quality, and the research on soybean flavor quality is not deep enough.

At present, the production of SPI basically adopts the traditional alkali dissolution and acid precipitation process, and the application of the product is limited because of the strong odor components of the product. These odor components are produced by oxidative degradation of unsaturated fatty acids in SPI residual lipids during processing and storage [5]. These residual lipids are covalently bound to protein and are usually not removed during the n-hexane degreasing of soybean meal [6]. There are some defects in the original food detection technology. On the one hand, due to technical limitations, it is impossible to detect various components, and only one component

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can be fixed, resulting in the inaccurate determination of some harmful components in food [7]. On the other hand, there is a big deviation in the measured data. Using the existing technology and testing equipment, there is a big deviation between the detected data results and the normal data values [8]. In this paper, the application of gas chromatography in the determination of flavor components in food industry was studied, and the flavor components of 10 SPI samples were analyzed in order to provide scientific basis for the breeding and processing of SPI flavor quality.

2. Materials and Methods

2.1 Sample Treatment

Low-temperature defatted soybean meal is provided by Shandong Yu Wang Industrial Co., Ltd. The selected soybean plants were sampled by eight-point method. Three soybean samples were mixed and mashed, and 10ml of the mashed sample solution was placed in a 15ml headspace bottle, and 1μl of internal standard was added. The aged 75μmCAR/PDMS extraction head was inserted into the headspace of the sample bottle and adsorbed at 45℃ for 30min. Dissolve SPI in deionized water, prepare 12% solution, put it in a container of solid-phase microextraction device, seal it and put it in a 500℃ oven for 1 hour. The adsorbed extraction head was taken out and inserted into the gas chromatography inlet of GC-MS, and desorbed at 250℃ for 5 minutes, and the instrument was started to collect data.

2.2 Methods

1) Instrument and gas chromatography-mass spectrometry method

TRACE MS gas chromatography-mass spectrometer (Finnigan Mass Spectrometry Company, USA). The reagents such as ethanol, chloroform, methanol, sodium hydroxide and hydrochloric acid are all AR grade. Chromatographic conditions: carrier gas He, flow rate 1ml/min. The initial temperature was 35℃, kept for 3min, then increased to 45℃ at 8℃/min, then increased to 140℃ at 6℃/min, and finally increased to 230℃ at 10℃/min, and kept for 6min. Mass spectrometry conditions: EI source, ion source temperature 200℃, electron energy 70eV, interface temperature 250℃, detector voltage 350V, emission current 200 μ A.. In the preparation and precooling stages, nitrogen gas enters from between the pyrolysis straw and the cold trap capillary. When there is no reaction, the purging gas directly enters the chromatographic column for cleaning. When there is reaction, the purging gas is divided into two ways to clean the pipeline at the same time, one way is discharged through the pyrolysis straw and the water condenser, and the other way is discharged into the chromatographic column through the cold trap capillary. The liquid helium valve is opened to precool the cold trap to the required temperature for trapping. After the purging starts, nitrogen gas is used as the purging gas to blow out volatiles from the purging bottle and enter the desorption straw through the water condenser. After the purging, the temperature of the cold trap was quickly raised to 200℃, and the volatiles entered the gas chromatography capillary in boiling point order for separation, and finally were detected by the flame photometric detector.

2) Analysis method of flavor components

The soybean sample solution was analyzed and identified by gas chromatography-mass spectrometry, and the total ion chromatogram was obtained. The chemical composition of soybean flavor components was determined by searching by computer Willey, Mainlib and other libraries, and checking with relevant literature according to the mass spectrum fragmentation diagram of each peak. The peak area normalization method was used to calculate the percentage content of each chemical component in flavor components. The relative content and concentration of internal standard were used for quantitative analysis of flavor components. After extracting for 2 hours, add an appropriate amount of anhydrous sodium sulfate into the extraction solvent and put it in the refrigerator overnight. Filtering the next day, concentrating with a concentrating column, heating in a water bath at 50℃, and controlling the split ratio to 5-6 drops /min. When the solvent in the bottle is less than 1mL, stop heating, let stand to make the solvent drop down in the column, with a total amount of about 3mL, and then transfer it to a solvent bottle for GC-MS analysis and identification.

3. Results and Analysis

3.1 Flavor Composition of Soybean Plants Tested

In the application of two-dimensional chromatography technology, combined with mild and sufficient pretreatment conditions and various sampling methods, it is a way to find out the composition of volatile flavor components in aquatic products by two-dimensional gas chromatography Because two-dimensional gas chromatography technology is more complicated in parameters and structure than one-dimensional gas chromatography, it is very important to establish a reasonable and rapid analysis method. The flavor components of 10 soybean samples were analyzed for two consecutive years, and more than 150 compounds in 12 categories were detected, as shown in Table 1.

Table 1. Main flavor components of soybean

Types of compounds	Nitriles	Esters	Aldehydes	Ketone	Hydrocarbon	Heterocycles
Quantity	17	15	17	16	18	8

It can be seen from Table 1 that in the test results, the number of main components varies from 6 to 20. It can also be seen from Table 1 that among the flavor components of soybean, nitriles are the most and heterocyclic compounds are the least. On the whole, these seven categories contain more compounds. Therefore, the main flavor components in soybean are composed of seven kinds of compounds: nitriles, esters, aldehydes, ketones, alcohols, hydrocarbons and heterocyclic compounds.

3.2 Characteristic Flavor Components of Soybean Plants Tested

Generally speaking, the longer the distillation time, the better the extraction effect, but too long the extraction time will reduce the working efficiency, and heating at high temperature for too long may change the components in the sample, resulting in certain losses. Among the rich flavor components of soybean, although there are many kinds, which vary greatly from year to year, five of them are ubiquitous in all the tested materials, and their relative contents are relatively high, as shown in Table 2.

Table 2. Characteristic flavor components of SPI

Compound	Relative percentage content (%)	Content (μg/L)
2- Cyclohexene -1- ol	0.04~38.88	2.73~3251.15
2- hexenal	0.22~9.55	12.32~863.73
3- hexene -1- ol	0~7.47	0~177.18
Phenethyl isothiocyanate	0.69~11.32	9.25~1181.66
Phenylpropionitrile	4.52~11.99	56.19~1527.71
Total	19.32~54.86	481.45~5851.67

Note: The data in the table refer to the variation range of the content of 10 tested varieties.

It can also be seen from Table 2 that the change range of the relative content of the sum of the five components is not the result of the accumulation of the maximum and minimum values of various substances. Although the annual performance of these five compounds is not exactly the same in the two-year experiment.

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However, in the two-year experiment, they are all the components with the highest relative content in all varieties, especially 2- cyclohexene -1- alcohol, which is the compound with the highest content. In different samples, the proportion of each compound is not exactly the same. In a test material, when a compound accounts for a large proportion, the relative percentage content of other components will decrease accordingly. It can't be said specifically which substance is the characteristic compound in the tested materials, but these five substances with relatively large content together constitute the characteristic flavor components of SPI.

4. Discussion

Flavor is one of the important indexes to evaluate the quality of vegetables, and the composition and content of flavor components are the key factors affecting the flavor quality of vegetables. The formation of flavor components is very complicated, and its sources are mainly various secondary products and small molecular end products produced by microbial enzymatic hydrolysis of macromolecular substances such as protein and starch in soybeans, metabolic products produced by microorganisms during fermentation, and products of complex biochemical and chemical reactions between these substances. These substances are not only their components, but also can react with other substances to generate aroma components such as pigments and esters. The soybean flavor components measured in this experiment are mainly nitriles, esters, alcohols, hydrocarbons, ketones, aldehydes and heterocyclic compounds, which together constitute the flavor components of soybean.

Because there are still some problems to be solved in gas chromatography, such as the complicated pretreatment process, if impurities can be removed from the gas chromatograph, the analysis speed can be greatly accelerated, at least some existing chemical pretreatment systems should be simplified. Because of the special consumption function and high component complexity of food, it is more important to analyze its flavor quality accurately. Five compounds such as 2- cyclohexene -1- ol, 2- hexenal, 3- hexene -1- ol (Z/E), phenylpropionitrile and phenylethyl isothiocyanate are the characteristic flavor components of SPI. These five substances are common in different samples, but their contents vary greatly, especially 2- cyclohexene -1- alcohol. It may be because the water content and various nutrients of different samples and the same samples are not the same in different years, and it is also affected by environmental conditions, which leads to differences in volatile flavor components.

Generally speaking, the threshold of alcohol compounds is high, so unless they exist in high concentration or are unsaturated, they will not contribute much to the flavor of food. But because it can further react with fatty acids to form esters, it can indirectly affect the flavor. Usually, alcohols have the odor of fragrance, plant fragrance and rancidity. Because of the different extraction and separation methods of samples, the results of flavor composition are different. Bernal et al. determined more than 10 kinds of volatile substances in three soybean samples of two different ecotypes. Dehelean et al. used different extraction methods to detect more than 30 compounds. Because the volatile components that affect the quality and flavor of vegetables are greatly influenced by environmental conditions, the tested materials should be cultivated under the same conditions. With the continuous improvement and development of two-dimensional gas chromatography technology, people pay more and more attention to the separation and analysis of complex systems, and the application of two-dimensional gas chromatography in volatile flavor analysis of various foods continues to expand. In this experiment, 10 soybean varieties were used to determine the flavor components of soybean in the same experimental site, different years and the same season, which can accurately reflect the main flavor components of soybean. Through the improvement of the existing model, not only the accuracy of the measured data is guaranteed, but also the measured data can be effectively controlled to prevent harm to human health.

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