Chapter 2
Quality Characteristics and Determination Methods of Peanut Raw Materials

As one of the major oilseed crops in the world, peanut is planted in more than 100 countries, but the sensory quality, nutritional quality, and processing characteristics of peanuts planted in different regions and of different varieties are significantly different. Some scholars have reported the basic composition and vitamin E and phytosterol contents of peanuts in China, the United States, India, Canada, and other regions (Dean et al. 2009; Özcan 2010; Wang et al. 2009, 2010). The research conducted by Shin et al. (2010a) found that among the 221 peanut varieties of the United States, the phytosterol content in the Spain peanuts (144.1 mg/100 g ± 5.3 mg/100 g) was significantly higher than that in Runner peanuts (127.5 mg/100 g ± 6.3 mg/100 g) and Virginia peanuts (129.3 mg/100 g ± 6.9 mg/100 g) ($P < 0.05$); the research conducted by Shin et al. (2010b) showed that there were significant differences in the composition of fatty acid in peanut varieties with normal oleic acid, medium oleic acid, and high oleic acid contents ($P < 0.05$); in addition, some varieties were selected due to their high protein content, high oleic acid content, or other processing characteristics.

In recent years, with the rapid development of peanut processing industry, the research on the peanut processing quality and functional characteristics has attracted widespread attention from the academic field, and the high protein and characteristic amino acid contents, scientific and reasonable fatty acid ratio modes, different protein components and subunit contents, high and low glycan contents, and other processing characteristics and functional indicators of peanut varieties have become important research fields. Wang et al. (2011) reported the protein, fat, and sucrose contents in various peanut varieties in different regions of China; Shokarii et al. (1991) reported the protein components and subunit composition of different peanut varieties. There are more than 7490 peanut germplasm resources and varieties in China, but limited systematic research has been conducted on the sensory quality, nutritional quality, and processing characteristics of peanuts of different varieties and regions. Therefore, it is of great significance to analyze the processing quality and functional characteristics of peanut varieties and make clear the relationship between peanut raw material quality and product quality for

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scientific and reasonable utilization of peanut resources and improvement of product quality.

1 Determination of Peanut Quality Indicators

To analyze the quality characteristics of representative peanut varieties in China comprehensively and systematically, this research team collected and analyzed 111 main cultivars in 12 major peanut planting provinces in China (Table 2.1). Among them, 59 cultivars were from Shandong, 13 from Henan, 10 from Guangdong, 9 from Fujian, 6 from Jiangsu, 6 from Hubei, 3 from Guangxi, 1 from Liaoning, 1 from Hebei, 1 from Hunan, 1 from Anhui, and 1 from Jiangxi.

A total of 80 indicators (7 sensory quality indicators, 60 physicochemical and nutritional quality indicators, and 13 processing quality indicators) (Table 2.2) of peanut were determined with reference to domestic and foreign literature (Hariprasanna et al. 2008; Misra 2004) and related standards. The means, variation coefficients, upper quartiles, medians, and lower quartiles of sensory quality, physicochemical and nutritional quality, and processing quality indicators were analyzed. The variation range showed the breadth of data coverage; the variation coefficient was the statistics to measure the degree of variation in the data; the upper quartile, median, and lower quartile could reflect the distribution of data. The above research ensured the accuracy and comprehensiveness of analytical data and reflected the quality characteristics of peanuts truly. The analysis results of specific data are described in the following sections, respectively.

2 Analysis of Sensory Quality

The sensory quality of peanut refers to the appearance characteristics of pod and seed kernel, including imperfect grain, metamorphic kernel, thousand grain weight, impurity, color, smell, rancid kernel, and other indicators which directly affect the consumption and utilization of peanuts. Based on the summary of domestic and foreign test methods for various quality indicators, this book determined and analyzed the sensory quality of 66 peanut varieties in China by using the standard determination method and defined the sensory quality situations of different peanut varieties in China basically.

Table 2.1 Name and source of 111 peanut varieties

No.	Name	Source	No.	Name	Source	No.	Name	Source
1	Zhonghua 8	Hubei	38	034-256-1	Shandong	75	Minhua 10	Fujian
2	Shanhua 7	Shandong	39	Ji 9814	Hebei	76	Huayu 36	Shandong
3	Silihong	Liaoning	40	Yuhua 15	Henan	77	Yuhua 14	Henan
4	Luhua 11	Shandong	41	Yuhua 9326	Henan	78	Xiangxiang	Shandong
5	Bianhua 3	Henan	42	Yuhua 9327	Henan	79	Luhua 2	Shandong
6	Haihua 1	Shandong	43	Kainong 30	Henan	80	Huayu HH017	Shandong
7	Shanhua 9	Shandong	44	Kainong 37	Henan	81	Yueyou 551	Guangdong
8	Shuangji 2	Shandong	45	Yuanza 9102	Henan	82	Quanhua 10	Fujian
9	Fenghua 5	Shandong	46	Zhongnong 108	Hubei	83	Quanhua 464	Fujian
10	Yueyou 14	Guangdong	47	Quanhua 551	Fujian	84	Quanhua 327	Fujian
11	Yueyou 40	Guangdong	48	Hua Guanwang	Shandong	85	Xiaopuyang	Shandong
12	Yueyou 45	Guangdong	49	Honghua 1	Shandong	86	Zhongkaihua 4	Guangdong
13	Yueyou 86	Guangdong	50	Qinglan 8	Shandong	87	Pingdu Dalidun	Shandong
14	Minhua 9	Fujian	51	Huayu 8	Shandong	88	Yuhua 11	Henan
15	Guihua 771	Guangxi	52	Luhua 14	Shandong	89	Heyou 4#	Shandong
16	Zhanhua 82	Fujian	53	Xuhua 15	Jiangsu	90	Shuangji 22	Shandong
17	Shanyou 250	Guangdong	54	Huayu 16	Shandong	91	Qinglan 2	Shandong
18	Longhua 243	Fujian	55	Zhonghua 4	Hubei	92	Qixia Laobaoji	Shandong
19	Heyou 11	Guangxi	56	Zhonghua 15	Hubei	93	Wenshangmansheng	Shandong
20	Pearl Red	Guangdong	57	Haiyu 6	Shandong	94	Guihua 95	Guangxi
21	White Peanut	Fujian	58	Lufeng 2	Shandong	95	Xuhua 3	Jiangsu
22	Fenghua 1	Shandong	59	Hongguan	Shandong	96	Qingdao Manshengdali	Shandong
23	Fenghua 3	Shandong	60	Yuanza 9307	Henan	97	Zhenghua 5	Henan
24	Fenghua 4	Shandong	61	Zhengnong 7	Henan	98	Luhua 10	Shandong
25	Xuhua 5	Jiangsu	62	Fenghua 6	Shandong	99	Qingdao Liman	Shandong

(continued)

Table 2.1 (continued)

No.	Name	Source	No.	Name	Source	No.	Name	Source
26	Yuanhua 8	Jiangsu	63	Luhua 9	Shandong	100	Qufu Doupeng	Shandong
27	Xuhua 13	Jiangsu	64	Luhua 15	Shandong	101	Zhufeng 1	Shandong
28	Xuhua 14	Jiangsu	65	Xianghua 509-77	Hunan	102	Dingtao Banmanyang Peanut	Shandong
29	Huayu 19	Shandong	66	Hua 17	Shandong	103	Zhaoyuan Banman	Shandong
30	Huayu 20	Shandong	67	Hua 27	Shandong	104	Pingdu Paman	Shandong
31	Huayu 22	Shandong	68	Luhua 12	Shandong	105	Yueyou 25	Guangdong
32	Huayu 23	Shandong	69	Baisha 101	Henan	106	Qixia Bankangpi	Shandong
33	Huayu 28	Shandong	70	Huayu 33	Shandong	107	Hua 55	Shandong
34	Huayu 31	Shandong	71	Huayu 25	Shandong	108	Jimo Paman	Shandong
35	Baisha 1016	Shandong	72	Luhua 10	Anhui	109	Pearl Black	Guangdong
36	Colorful Peanut	Hubei	73	Lanhua 2	Shandong	110	Shuanghong 2	Shandong
37	Black Peanut	Hubei	74	Huayu 32	Shandong	111	Ganhua 7	Jiangxi

Table 2.2 Peanut quality indicators

Sensory quality	Physicochemical and nutritional quality	Processing quality
Fruit shape, red skin, grain shape, shape, smell, hundred fruit weight, and hundred kernel weight	Water, crude fat, crude protein, total sugar, ash, crude fiber, total amino acids, 18 kinds of amino acids (aspartic acid, threonine, serine, glutamic acid, proline, glycine, alanine, cysteine, valine, methionine, isoleucine, leucine, tyrosine, phenylalanine, lysine, histidine, and arginine), protein composition content and subunit content (arachin, conarachin, conarachin I, conarachin II, 40.5 kDa, 37.5 kDa, 35.5 kDa, 23.5 kDa, 18 kDa, 17 kDa, 15.5 kDa), fatty acids (13, including oleic acid, linoleic acid, etc.), V_E, sterol, and squalene	Pure kernel rate, oil yield, protein extraction rate, oleic acid/linoleic acid, unsaturated fatty acids/saturated fatty acids, and arachin/conarachin

2.1 Determination Methods

2.1.1 Imperfect Fruit, Immature Fruit, Broken Fruit, Insect-Damaged Fruit, Damaged Fruit, and Imperfect Grain (Insect-Damaged Grain, Diseased Grain, Germinative Grain, Broken Grain, Immature Grain, and Damaged Grain)

1. Domestic standard: GB/T 5494-2008 Determination of foreign matter and unsound kernels of grain and oilseeds
2. Methods of American Peanut Council: Shelling and grading

2.1.2 Metamorphic Kernel (Moldy Grain, Thermal Loss Grain, Discolored Grain, Oily Grain, Spotty Grain, and Other Damaged Grains)

1. Domestic standard: SN/T 0798-1999 Inspection of cereals, oils, and feedstuffs for import and export – Terminology for inspection
2. Standard of International Code Council: Codex Stan 200-1995 Codex Standard for Peanuts

2.1.3 Thousand Grain Weight

1. Domestic standard: GB/T 5519-2008 Cereals and pulses – Determination of the mass of 1000 grains
2. Foreign standard: None

2.1.4 Impurity

1. Domestic standard: GB/T 5494-2008 Determination of foreign matter and unsound kernels of grain and oilseeds
2. Foreign standard: None

2.1.5 Color

1. Domestic standard: GB/T 5492-2008 Inspection of grain and oilseeds – Methods for identification of color, odor, and taste
2. Methods of American Peanut Council: Shelling and grading

2.1.6 Smell

1. Domestic standard: GB/T 5492-2008 Inspection of grain and oilseeds – Methods for identification of color, odor, and taste
2. Foreign standard: No standard

2.1.7 Whole Half Peanut Kernel

1. Domestic standard: GB/T 1532-2008 Peanut
2. Foreign standard: None

2.1.8 Different Variety Rate

1. Domestic standard: SN/T 0803.4-1999 Oil-bearing materials for import and export – Method for the inspection of type purity and their mixture
2. Foreign standard: None

2.1.9 Peanut Kernel Size

1. Domestic standard: NY/T 1893-2010 Grades and specifications of peanuts for processing
2. Methods of American Peanut Council: Shelling and grading

2.1.10 Rancid Kernel

1. Domestic standard: None
2. Methods of American Peanut Council: Shelling and grading

2.2 Data Analysis

This research team collected 66 peanut varieties in Table 2.1 for analysis. These 66 varieties were from 10 provinces, 30 from Shandong, 9 from Henan, 6 from Hubei, 6 from Guangdong, 5 from Fujian, 5 from Jiangsu, 2 from Guangxi, 1 from Liaoning, 1 from Hunan, and 1 from Hebei (Table 2.3).

The research and analysis (Table 2.4) found that there were no significant differences in the shape and smell of different varieties of peanuts, while the differences of grain shape, fruit shape, hundred fruit weight, and other two indicators were significant. The maximum variation coefficient of peanut grain shape was 74.54%, which indicated that the difference of grain shape of each variety was large. Through comparison between the mean and median, it was found that the data variations of all indicators were very small, except that of grain shape, which indicated that these indicators of various varieties were evenly distributed and had no extreme value basically; while the data variation of grain shape was large, which indicated that the differences of grain shapes of different peanut varieties were large and several varieties had extreme shapes, for example, the oval peanut varieties accounted for 40% of the varieties analyzed and only Fenghua 6 peanuts were cocoon-shaped peanuts. The maximum hundred fruit weight was 285.00 g and the minimum was 114.80 g. After the average value of hundred fruit weight of peanuts in different areas was analyzed, it was found that peanut varieties in Shandong had the highest value of hundred fruit weight; among the top ten, six varieties were from Shandong, and they were Fenghua 5, Shuangji 2, Huayu 19, Shanhua 9, Shanhua 7, and Huayu 31. The peanut varieties in Guangdong, Fujian, and the south had the lowest average value of hundred fruit weight; the peanut varieties whose value of hundred fruit weight was ranked in the last ten were Yueyou 86, Colorful Peanut, Zhanhua 82, Minhua 9, Shanyou 250, Yueyou 14, Yueyou 20, Longhua 243, Guihua 771, and Pearl Red.

3 Analysis of Physicochemical and Nutritional Quality

The physicochemical and nutritional quality of peanut is the intrinsic quality characteristic of peanut which is closely related to the nutritional value and functional characteristics of peanut, and it specifically includes crude protein, crude fat, crude fiber, ash, total sugar, amino acid, fatty acid, vitamin E, phytosterol, squalene, resveratrol, and other indicators. Based on the summary of domestic and foreign

Table 2.3 Name and source of 66 peanut varieties

No.	Variety name	Variety source	No.	Variety name	Variety source	No.	Variety name	Variety source
1	Zhonghua 8	Hubei	23	Fenghua 3	Shandong	45	Yuanza 9102	Henan
2	Shanhua 7	Shandong	24	Fenghua 4	Shandong	46	Zhongnong 108	Hubei
3	Silihong	Liaoning	25	Xuhua 5	Jiangsu	47	Quanhua 551	Fujian
4	Luhua 11	Shandong	26	Yuanhua 8	Jiangsu	48	Huaguanwang	Shandong
5	Bianhua 3	Henan	27	Xuhua 13	Jiangsu	49	Honghua 1	Shandong
6	Haihua 1	Shandong	28	Xuhua 14	Jiangsu	50	Qinglan 8	Shandong
7	Shanhua 9	Shandong	29	Huayu 19	Shandong	51	Huayu 8	Shandong
8	Shuangji 2	Shandong	30	Huayu 20	Shandong	52	Luhua 14	Shandong
9	Fenghua 5	Shandong	31	Huayu 22	Shandong	53	Xuhua 15	Jiangsu
10	Yueyou 14	Guangdong	32	Huayu 23	Shandong	54	Huayu 16	Shandong
11	Yueyou 40	Guangdong	33	Huayu 28	Shandong	55	Zhonghua 4	Hubei
12	Yueyou 45	Guangdong	34	Huayu 31	Shandong	56	Zhonghua 15	Hubei
13	Yueyou 86	Guangdong	35	Baisha 1016	Shandong	57	Haiyu 6	Shandong
14	Minhua 9	Fujian	36	Colorful Peanut	Hubei	58	Lufeng 2	Shandong
15	Guihua 771	Guangxi	37	Black Peanut	Hubei	59	Hongguan	Shandong
16	Zhanhua 82	Fujian	38	034-256-1	Shandong	60	Yuanza 9307	Henan
17	Shanyou 250	Guangdong	39	Ji 9814	Hebei	61	Zhengnong 7	Henan
18	Longhua 243	Fujian	40	Yuhua 15	Henan	62	Fenghua 6	Shandong
19	Heyou 11	Guangxi	41	Yuhua 9326	Henan	63	Luhua 9	Shandong
20	Pearl Red	Guangdong	42	Yuhua 9327	Henan	64	Luhua 15	Shandong
21	White Peanut	Fujian	43	Kainong 30	Henan	65	Xianghua 509-77	Hunan
22	Fenghua 1	Shandong	44	Kainong 37	Henan	66	Huayu 17	Shandong

Table 2.4 Descriptive analysis of sensory quality of peanut

Factor	Variation range	Mean	Variation coefficient/%	Upper quartile	Median	Lower quartile	Data variation/%
Fruit shape	1.00∼8.00	5.07 ± 1.86	36.78	4.00	5.00	7.00	1.38
Red skin	1.00∼9.00	5.47 ± 1.46	26.62	5.00	6.00	6.00	9.69
Grain shape	1.00∼5.00	2.40 ± 1.79	74.54	1.00	1.00	5.00	58.33
Hundred fruit weight	114.80∼285.00	183.07 ± 43.42	23.72	149.50	183.50	213.80	0.23
Hundred kernel weight	38.6∼120	72.16 ± 18.64	25.83	57.75	71.90	85.20	0.36

test methods for physicochemical and nutritional quality of peanut, this book determined and analyzed the physicochemical and nutritional quality of 66 peanut varieties in China by using the standard determination methods and then preliminarily defined the physicochemical and nutritional quality of different peanut varieties in China.

3.1 Determination Method

3.1.1 Crude Protein

1. Domestic standard: GB 5009.5-2010 Determination of protein in foods
2. AOAC standard: AOAC Official Method 950.48 Protein (Crude) in Nuts and Nut Products

3.1.2 Crude Fat

1. Domestic standard: GB/T 5009.6-2016 Determination of fat in foods
2. AOAC standard: AOAC Official Method 948.22 Fat (Crude) in Nuts and Nut Products

3.1.3 Crude Fiber

1. Domestic standard: GB/T 5515-2008/ISO 6865:2000 Determination of crude fiber content in grain – Method with intermediate filtration
2. (2) AOAC standard: AOAC Official Method 962.09 Fiber (Crude) in Animal Feed and Pet Food

3.1.4 Water

1. Domestic standard: GB 5009.3-2016 Determination of moisture in food
2. AOAC standard: AOAC Official Method 925.40 Loss on Drying (Moisture) in Nuts and Nut Products

3.1.5 Ash

1. Domestic standard: GB 5009.4-2016 Determination of ash in foods
2. AOAC standard: AOAC Official Method 950.49 Ash of Nuts and Nut Products

3.1.6 Total Sugar

1. Domestic standards:

   Reducing sugar: GB/T 5009.7-2016 Determination of reducing sugar in foods
   Sucrose: GB/T 5009.8-2016 Determination of fructose, glucose, sucrose, maltose, and lactose in foods
   Starch: GB/T 5009.9-2016 Determination of starch in foods
   Total sugar: There is no standard and the phenol sulfuric acid method is adopted mostly. Colorimetric method for determination of sugars and related substances

2. AOAC standard:

   Reducing sugar: AOAC Official Method 950.50 Sugars (Reducing) in Nuts and Nut Products
   Sucrose: AOAC Official Method 950.51 Sucrose in Nuts and Nut Products
   Starch: AOAC Official Method 920.40 Starch in Animal Feed
   Total sugar: There is no standard and the phenol sulfuric acid method is adopted mostly. Colorimetric method for determination of sugars and related substances

3.1.7 Amino Acid

1. Domestic standard: GB/T 5009.124-2016 Determination of amino acids in foods
2. AOAC standard: AOAC Official Method 994.12 Amino Acids in Feeds

3.1.8 Fatty Acid

1. Domestic standard: GB/T 5009.168-2016 Determination of fatty acids in foods
2. AOAC standard: AOAC Official Method 996.06 Fat (Total, Saturated, and Unsaturated)

3.1.9 Vitamin E

1. Domestic standard: GB 5009.82-2016 Determination of VE, VA, and VD in foods
2. AOAC standard: AOAC Official Method 971.30 α-Tocopherol and α-Tocopheryl Acetate in foods and Feeds

3.1.10 Phytosterol

1. Domestic standard: GB/T 25223-2010/ISO 12228: 1999 Animal and vegetable fats and oils – Determination of individual and total sterols contents – Gas chromatographic method
2. AOAC Standard: AOAC Official Method 967.18 Beta-Sitosterol in Butter Oil

3.1.11 Squalene

1. Domestic standard: None
2. AOAC standard: AOAC Official Method 943.04 Squalene in Oils and Fats

3.1.12 Resveratrol

1. Domestic standard: GB/T 24903-2010 Inspection of grain and oils – Determination of resveratrol in peanut by high-performance liquid chromatography
2. AOAC standard: None

3.2 Data Analysis

3.2.1 Basic Component Analysis

Crude fat, crude protein, total sugar, ash, crude fiber, and water are the main components of peanut, and they are also known as the basic components of peanut. The contents and variation ranges of the various peanut varieties researched and analyzed by this team are listed in Table 2.5. It could be seen that the water contents of the selected peanut varieties were all within the safe range (9%) (Codex Stan 200-1995), the variation range of total sugar was the widest (2.87–12.59%), the variation range of crude fat was 42.11–58.59%, and the variety with the highest content was Yuhua 9327. The variation range of crude protein was 21.42–31.40%, and the variety with the widest variation range was Longhua 243. The research results of Cobb and Johnson (1973) showed that the average crude fat content of peanuts in the United States was 50% and the variation range was 44–56%. Jonnala et al. (2005) found that the variation range of peanut fat was 42–49%, that of protein was 25–29% and that of crude fiber was 9–12%. Teng et al. (2003) found that the variation range of peanut fat content was 39.96–58.64%. Luo et al. (2004) analyzed the sugar content of 13 peanut varieties and found that the variation range of sucrose was 5.1–5.9%. From the comparison between domestic and foreign research results, it could be found that the coverage of data variation range of peanut varieties in the research conducted by this team was wider, and the research results showed that the data variation of six basic components of peanut was less than 4%, which indicated that the data of selected peanut varieties was distributed evenly.

Table 2.5 Analysis of physicochemical and nutritional quality of peanut

Factor	Variation range	Mean	Variation coefficient/%	Upper quartile	Median	Lower quartile	Data variation/%
Water	3.71–7.41	5.47 ± 0.95	17.43	4.71	5.36	6.18	2.01
Crude fat	42.11–58.59	51.22 ± 3.40	6.63	49.29	51.24	53.59	0.04
Crude protein	21.42–31.40	25.79 ± 2.06	7.97	24.37	25.78	27.09	0.04
Total sugar	2.87–12.59	7.30 ± 2.56	35.08	5.02	7.03	9.59	3.70
Ash	2.19–3.46	2.57 ± 0.20	7.86	2.45	2.56	2.65	0.39
Crude fiber	1.50–6.90	2.53 ± 0.82	32.28	2.10	2.50	2.80	1.19

From the analysis of basic components of selected peanuts in different areas (Table 2.6), it was found that there were significant differences in water, ash, crude fat, crude protein, and total sugar, respectively. The peanut varieties with the highest water content were from Fujian and Guangdong, and the means were 6.78% and 6.17%, respectively. The varieties with high crude fat content were from Henan and Jiangsu, and the means were 53.52% and 53.00%, respectively. The peanut varieties ranked in the first five places were Yuhua 9327, Xuhua 13, Yuhua 15, Yuanza 9102, and Xuhua 14. The peanut varieties from Fujian and Guangdong had high protein content, and the average contents were 29.79% and 30.34%, respectively. The peanut varieties ranked in the first five places were Longhua 243, Pearl Red, Shanyou 250, Yueyou 45, and Yueyou 86, which indicated that the differences of basic components of peanut varieties in different areas were large, and the result provided the basis for reasonable utilization of various peanut varieties.

3.2.2 Analysis of Amino Acid Content

The amino acid content in peanuts is usually determined by using the amino acid automatic analyzer or high-performance liquid chromatography, but these two methods are not suitable for the determination of mass samples and selection of breeding materials due to slow analysis speed and high cost; the near-infrared spectroscopy technology has been widely used in nondestructive test of agricultural products, especially in the analysis of crop quality, but the reports on determination of amino acid in peanuts using this technology do not exist at home and abroad. Therefore, based on the preliminary investigation and mass varieties' collection, this research team built the prediction model of amino acid content in peanuts by using the near-infrared analysis technology, carried out sufficient validation, and thus established near-infrared rapid test methods for amino acid in peanuts to provide rapid and nondestructive peanut amino acid test methods to peanut

Table 2.6 Analysis of physicochemical and nutritional quality of peanuts in different provinces

Producing area	Water	Ash	Crude fat	Crude protein	Crude fiber	Total sugar
Shandong	4.96 ± 0.66 b	2.58 ± 0.16 ab	51.07 ± 3.08 ab	27.03 ± 2.13 c	2.65 ± 1.14 a	7.85 ± 2.45 ab
Henan	5.27 ± 0.83 b	2.71 ± 0.32 a	53.00 ± 3.83 a	26.43 ± 1.60 c	2.40 ± 0.37 a	7.23 ± 3.09 ab
Guangdong	6.17 ± 0.65 a	2.55 ± 0.10 ab	49.41 ± 2.23 b	29.79 ± 1.07 ab	2.55 ± 0.64 a	6.28 ± 2.31 ab
Jiangsu	5.20 ± 1.10 b	2.39 ± 0.20 b	53.52 ± 2.43 a	28.07 ± 1.38 bc	2.78 ± 0.13 a	5.54 ± 2.58 b
Fujian	6.78 ± 0.64 a	2.45 ± 0.08 b	48.21 ± 3.15 b	30.34 ± 2.59 a	2.20 ± 0.67 a	8.69 ± 2.27 a

Note: a, b and c refer to the different levels in the same column ($p < 0.05$)

processing enterprises and breeding experts so as to promote better development of peanut industry in China.

3.2.2.1 Amino Acid Content

Amino acid is the basic composition unit of protein, and the difference of amino acid types and contents in different peanut varieties may lead to the difference of functional characteristics of protein. This team analyzed the amino acid content in 111 different peanut varieties by using the amino acid automatic analyzer; the analysis atlas is shown in Fig. 1, Appendix 4, and the analysis results are shown in Table 2.7. It could be seen that the mean of total amount of amino acids in 111 peanut varieties analyzed was 26.44 g/100 g (the number of g of amino acids in 100 g of peanuts) and the variation range was 19.08–45.53 g/100 g; the variation range of glutamic acid was the widest (2.05–6.12 g/100 g), and the mean was 4.23 g/100 g. The variation range of tryptophan was the smallest (0.16–0.42 g/100 g), and the mean was 0.25 g/100 g. The variation range of lysine was 0.77–1.60 g/100 g, that of methionine was 0.09–0.71 g/100 g and that of threonine was 0.40–1.15 g/100 g. The research results of Dean et al. (2009) showed that the variation range of lysine was 0.49–1.08 g/100 g, that of methionine was 0.09–0.57 g/100 g and that of threonine was 0.12–1.01 g/100 g, which were consistent with the results of this research.

The variation range of arginine content in peanuts was 2.38–5.45 g/100 g with a mean of 3.14 g/100 g (Table 2.7). Arginine was a nonessential amino acid, but it was closely related to the vascular health (Gornik and Creager 2004; Moriguti et al. 2005). Andersen et al. (1998) found that peanut was the main source of arginine, and the variation range was 1.50–4.32 g/100 g. The research conducted by Young and Mason (1972) showed that the total arginine content (free and non-free) could play an important role in selecting other more potential amino acid varieties, while free arginine was used as a sign of maturity of peanut seed, which might be largely related to the particular gene.

3.2.2.2 Characteristic Amino Acids

From the average content of amino acids, it was found that the contents of aspartic acid (3.07 g/100 g $\pm$ 0.60 g/100 g), glutamic acid (4.23 g/100 g $\pm$ 0.64 g/100 g), and arginine (3.14 g/100 g $\pm$ 0.53 g/100 g) were significantly higher than the contents of other amino acids (Fig. 2.1). The results were consistent with those reported in the literature (Dawson et al. 1971; Basha and Cherry 1976).

From the analysis of contents of 18 kinds of amino acids in soybean, peanut, rapeseed, rice, wheat, corn, and other crops (Fig. 2.2), it could be found that the glutamic acid content in various samples was high, the contents of aspartic acid and arginine in peanuts were significantly higher than those in other crops, and the

Table 2.7 Amino acid content in peanut. Unit: g/100 g

	Number of samples	Variation range	Mean ± standard deviation	Variation coefficient/%
Total amino acid	111	19.08–45.53	26.44 ± 4.88	18.440
Aspartic acid	111	2.22–5.42	3.07 ± 0.60	19.60
Threonine	111	0.40–1.15	0.70 ± 0.14	19.52
Serine	111	0.81–2.21	1.25 ± 0.27	21.79
Glutamic acid	111	2.05–6.12	4.23 ± 0.64	15.14
Proline	111	0.79–1.73	1.22 ± 0.20	16.12
Glycine	111	1.11–2.58	1.52 ± 0.30	19.68
Alanine	111	0.63–1.38	1.08 ± 0.35	18.58
Cystine	111	0.35–1.14	0.70 ± 0.23	32.22
Valine	111	0.90–1.76	1.19 ± 0.16	13.05
Methionine	111	0.09–0.71	0.33 ± 0.12	36.62
Isoleucine	111	0.71–1.53	0.97 ± 0.16	16.28
Leucine	111	1.28–3.05	1.77 ± 0.33	18.76
Tyrosine	111	0.46–1.89	1.08 ± 0.33	30.64
Phenylalanine	111	0.80–2.45	1.49 ± 0.25	16.53
Lysine	111	0.77–1.60	1.02 ± 0.14	13.37
Histidine	111	0.47–1.00	0.65 ± 0.11	17.26
Tryptophan	111	0.16–0.42	0.25 ± 0.05	19.51
Arginine	111	2.38–5.45	3.14 ± 0.53	16.97

contents of these two amino acids in peanuts were high, so these two amino acids were the characteristic amino acids of peanut.

3.2.2.3 Near-Infrared Fingerprint

Place the samples for spectral acquisition in the same laboratory with the near-infrared spectrometer for more than 24 h, so that the environmental conditions of samples are consistent with that of instrument to reduce the impact of temperature on the samples. Clean each sample to remove impurities and broken particles without further pretreatment. Turn on the near-infrared spectrometer to preheat for 30 min under 25 °C, place the samples evenly directly by hands using the natural loading method, fill with the sample cups, scan each sample twice and repeat loading three times, and take the average spectral acquisition method to overcome the sample heterogeneity and collect as much sample information as possible. Store the calculated mean of near-infrared absorption spectrum in the computer for further use of establishment of amino acid calibration model.

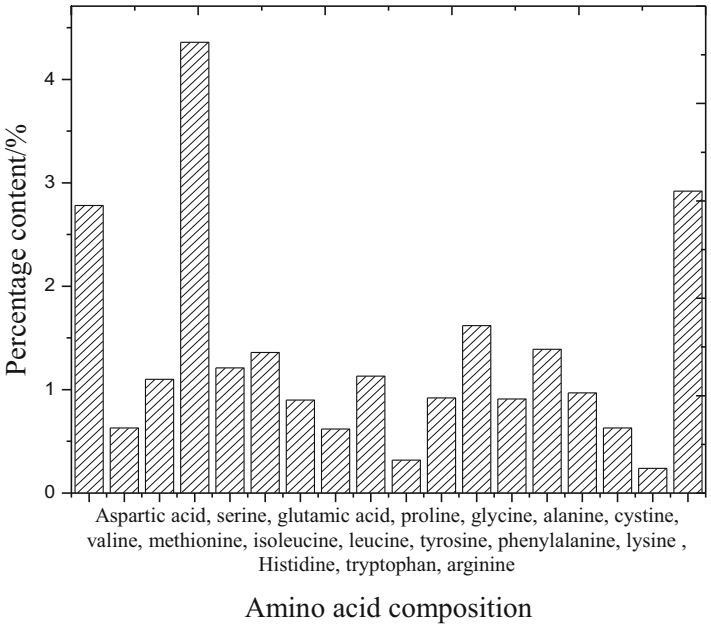


Fig. 2.1 Analysis of amino acid content in peanut

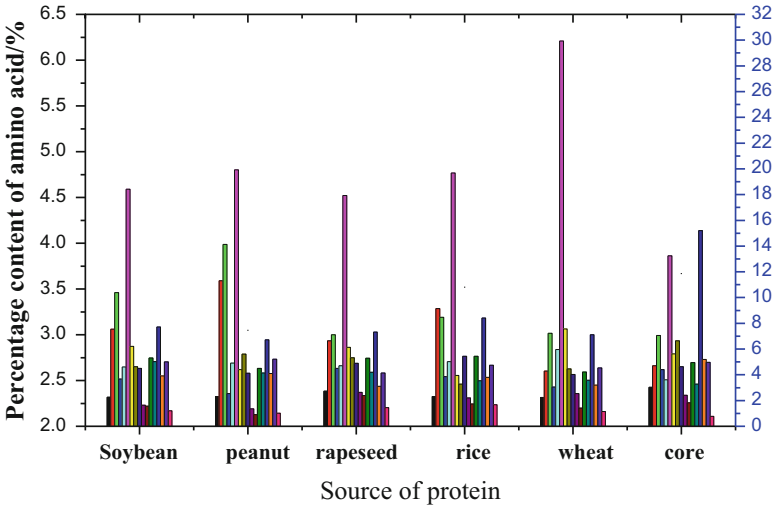


Fig. 2.2 Analysis of amino acid in peanut and other crops (lysine, histidine, aspartic acid, threonine, serine, glutamic acid, proline, glycine, alanine, cystine, methionine, valine, isoleucine, bright ammonia acid, tyrosine, phenylalanine, and tryptophan from *left* to *right*)

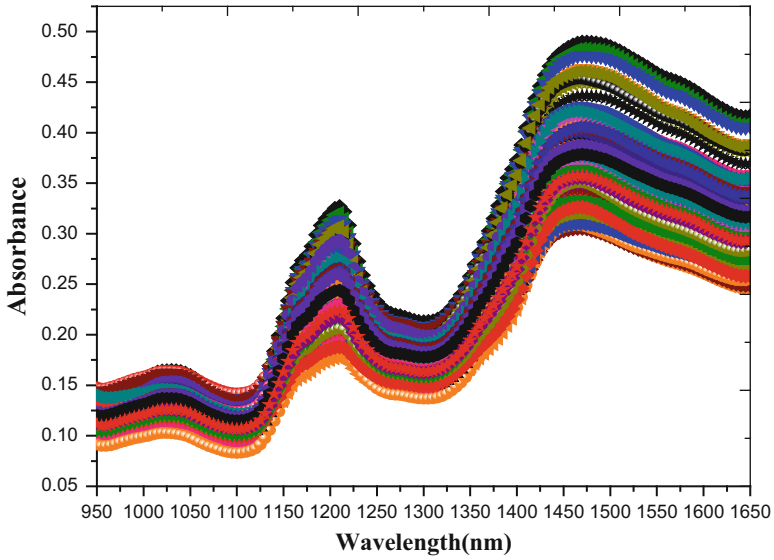


Fig. 2.3 Original absorption spectrums of peanut samples

1. Near-Infrared Characteristic Spectrum

Figure 2.3 shows the original near-infrared absorption spectrums of 111 peanut samples in the 950–1650 nm spectral region. The figure showed that there were three absorption peaks: the first peak was in 975–1025 nm, and it referred to the secondary frequency multiplication of O-H and N-H bond stretching vibration and third-level frequency multiplication of C-H bond stretching; there was a strong absorption band at 1210 nm, and it might be a secondary frequency multiplication absorption band of C-H bond stretching vibration; there was a strong absorption peak at 1460 nm, and it might be a first-level frequency multiplication absorption band of N-H bond stretching vibration, which were caused by a large amount of fat and protein in the peanut kernels (Song et al. 2011; Hourant et al. 2000).

2. Analysis of Principal Components of Infrared Spectrum Data

The near-infrared spectrum data represents a series of multivariates which contain many overlapping information. The multivariate statistical analysis is to extract some useful information in the original data to reduce the dimensionality of data. The principal component obtained after principal component analysis is a linear combination of original data. The cumulative contribution rate of the first two principal components in this research was 98.96% which was greater than 95%, so they could reflect the information of original data completely (Serudo et al. 2007). Therefore, the first two principal components were used to establish the regression model.

In order to understand the near-infrared spectrum classification of peanut samples in different regions preliminarily, a scatter diagram had been made by using the scores of the first and second principal components of near-infrared spectrum data

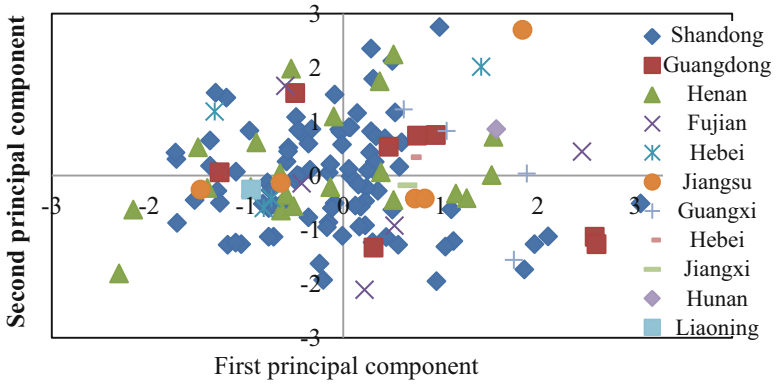


Fig. 2.4 Scatter diagram of first two principal components of near-infrared spectrum data of peanut

of peanut (Fig. 2.4). From the diagram, it could be seen that the spatial distribution limit of peanut samples in various provinces was not very obvious, but the samples in different provinces occupied their own spaces, which initially indicated that the peanut samples in different regions were very different.

3. Spectrum Data Preprocessing

In the near-infrared spectrum analysis, in order to eliminate the errors caused by sample heterogeneity, high-frequency random noise, baseline drift, stray light, and other factors, different spectrum preprocessing methods were used to process the spectrums and then establish the model, which could improve the accuracy and reliability of the model (Chu et al. 2004). Figure 2.5 is the second-derivative diagram of peanut samples. It could be seen from the figure that the fineness of spectrum had been improved significantly and the spectrum contour was clearer. A referred to the second overtone of O–H and N–H and the third overtone of C–H; B, C, and D were generated by C–H bond stretching vibration, O–H bond bonding vibration, and O–H bond denaturation overtone, respectively; E referred to the first overtone of O–H bond and N–H bond in the amino group.

4. Near-Infrared Prediction Model of Amino Acids

Seventy-four varieties were randomly selected as the modeling sample set from the 111 varieties in Table 2.1, 37 varieties were selected as the modeling validation sample set, the model was established by using PCA and PLS, and the internal cross validation and external validation were conducted to verify the model reliability. The internal cross validation is to remove one or more samples crosswise each time, predict the samples to be removed by modeling with other samples in turn, and measure the model quality by comparing the predicted values and chemical values R^2 and RESECV of samples. The external validation is to verify the model by using the samples that are not involved in modeling.

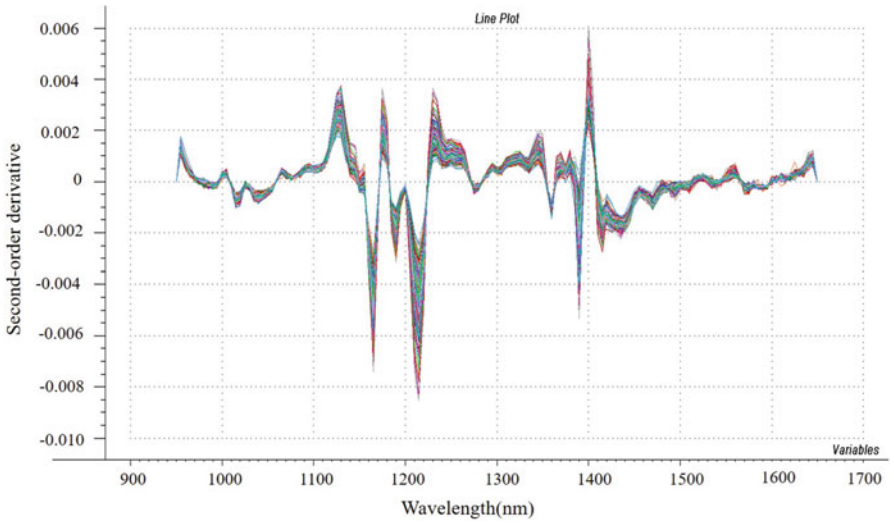


Fig. 2.5 Second-derivative diagram of peanut sample

The internal cross validation and external validation results of NIRS prediction models of eight kinds of amino acids (Table 2.8) showed that the variation range of different amino acids R^2 was 0.83–0.96; the variation range of RPD was 2.35–7.50 (R^2 of other amino acids was less than 0.80, and RPD values were less than 2 or more than 10, which were not listed). The research results of Williams and Norris (2001) showed that the model whose variation range of R^2 of NIRS prediction model was 0.83–0.95 and RPD value was 2–10 was reliable.

The scatter diagram of predicted values and true values of eight kinds of amino acids (Asp, Thr, Ser, Glu, Gly, Leu, Arg, and Cys) through the external validation of 37 varieties is shown in Fig. 2.6. The results showed that the correlation coefficient of predicted value and true value of each amino acid was greater than 0.90.

3.2.3 Analysis of Relative Contents of Protein Component and Subunit (SDS-PAGE Method)

3.2.3.1 Protein Extraction Method

The peanut protein was extracted by using alkali extraction and acid precipitation method, phosphate buffer method, and Tris-HCl method; the extraction rate and purity of protein extracted by using these three methods were calculated, and the polyacrylamide gel electrophoresis (SDS-PAGE) (Table 2.9) analysis was carried out for the protein prepared by using these three methods. From the table, it could be seen that the obtained electrophoretograms of peanut protein extracted by using these three methods were consistent; the extraction rate and purity of protein extracted by alkali extraction and acid precipitation method were higher than

Table 2.8 Prediction and validation results of amino acid in peanut

	Predicted set					Verified set				
Parameter	R_c^2	RMSE	R^2	RMSEV	SD/RMSE	SEP	R_v^2	Bias	Slope	RPD
Asp	0.88	0.18	0.6	0.34	1.56	0.21	0.84	−0.033	1.106	2.52
Thr	0.83	0.03	0.77	0.04	2.25	0.03	0.82	0.006	1.023	3.00
Ser	0.86	0.09	0.54	0.17	1.41	0.1	0.82	−0.011	1.11	2.40
Glu	0.87	0.45	0.54	0.86	1.47	0.49	0.85	0.063	1.085	2.57
Gly	0.88	0.09	0.55	0.18	1.44	0.11	0.82	−0.003	1.047	2.36
Leu	0.88	0.09	0.61	0.17	0.88	0.05	0.81	−0.033	0.983	3.00
Arg	0.89	0.16	0.66	0.29	1.69	0.17	0.86	−0.028	1.059	2.88
Cys	0.96	0.01	0.94	0.02	3.50	0.004	0.995	0.000	0.992	7.50

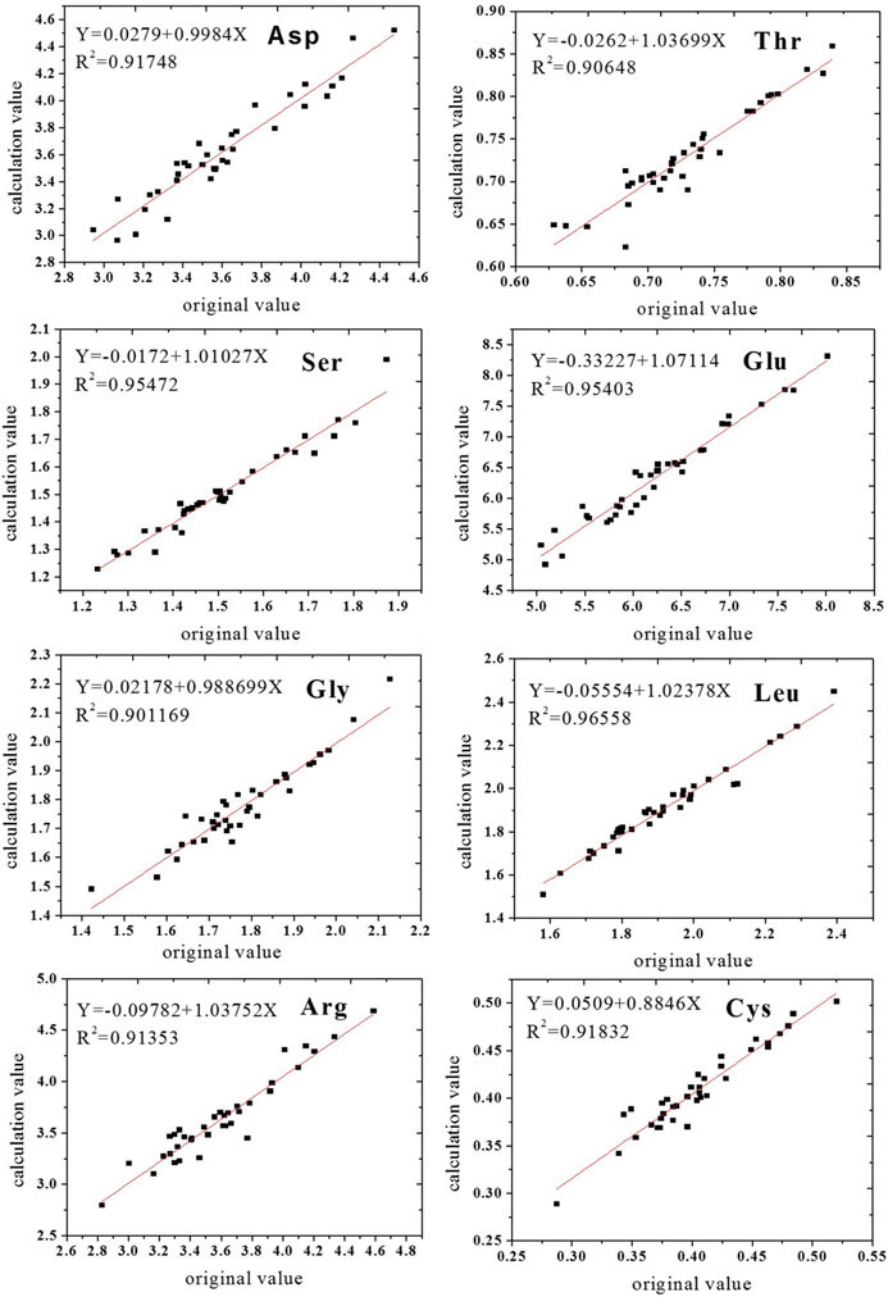
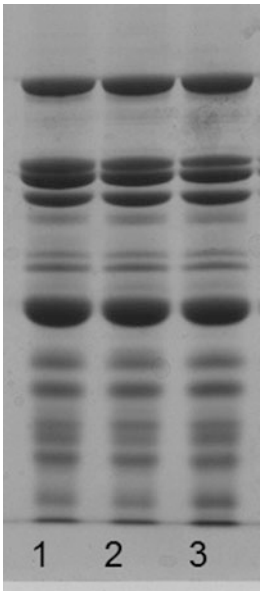


Fig. 2.6 Scatter diagram of true values and predicted values of amino acids in peanut

Table 2.9 Extraction rate, purity, and electrophoretogram of protein extracted by different extraction methods

Extraction method	Extraction rate	Purity	Electrophoretogram
Alkali extraction and acid precipitation	65%	92%	
Phosphate buffer	62%	88%	(1) Alkali extraction and acid precipitation method, (2) phosphate buffer method, (3) Tris-HCl method
Tris-HCl	61%	55%	

those of protein extracted by the other two methods, and this method was convenient for industrialized production. From the above, the alkali extraction and acid precipitation method was used to prepare protein for the further research.

3.2.3.2 Main Component and Relative Content of Protein

Main Components and Relative Contents of Protein in Different Varieties of Peanuts

The peanut protein included arachin and conarachin, and the conarachin contains conarachin I and conarachin II (Yamada 1979; Prakash and Rao 1986). From Fig. 2.7, it could be seen that each peanut variety contained arachin, conarachin I, and conarachin II.

The analysis of relative contents of protein components and subunits of 111 peanut varieties is shown in Tables 2.10 and 2.11. It could be seen from the tables that the variation coefficients of conarachin I and conarachin II contents were large, and they were 11.51% and 13.40%, respectively.

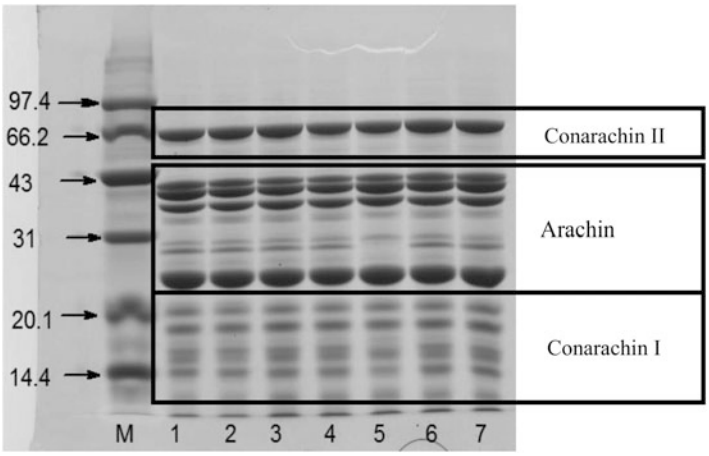


Fig. 2.7 Protein components of different peanut varieties

Table 2.10 Descriptive analysis of contents of peanut protein components

		Variation range/%	Mean/% ± standard deviation	Variation coefficient/%
Arachin	Total content	46.40–62.70	56.00 ± 3.79	6.77
Conarachin	Total content	37.30–53.50	43.98 ± 3.81	8.67
	Conarachin I	20.90–33.40	25.16 ± 2.90	11.51
	Conarachin II	13.40–25.30	18.82 ± 2.52	13.40

Table 2.11 Analysis of contents of peanut protein subunits

		Variation range/%	Mean/% ± standard deviation	Variation coefficient/%
Arachin	40.5 kDa	7.70–14.50	10.61 ± 1.74	16.38
	37.5 kDa	10.50–17.90	13.99 ± 1.68	11.99
	35.5 kDa	0.00–19.20	9.43 ± 5.86	62.14
	23.5 kDa	18.70–26.50	21.97 ± 1.78	8.11
Conarachin	61 kDa	13.40–25.30	18.82 ± 2.52	13.40
	18 kDa	6.60–11.40	8.71 ± 1.34	15.41
	17 kDa	6.90–13.20	9.56 ± 1.40	14.63
	15.5 kDa	3.70–11.90	6.90 ± 1.37	19.89

Peanut protein is usually composed of eight subunits. The arachin has four subunits with the molecular weights of 40.5, 37.5, 35.5, and 23.5 kDa, respectively; the conarachin II has one subunit with the molecular weight of 61 kDa; the

conarachin I has three subunits with the molecular weights of 15.5, 17, and 18 kDa, respectively (Fig. 2.7).

The SDS-PAGE atlas of 111 peanut varieties is shown in Fig. 2, Appendix 4. It could be seen from the figure that the number of conarachin subunits of different peanut varieties was consistent without differences, but there were differences in the number of arachin subunits. The arachin of some peanut varieties lacks 35.5 kDa subunits, such as Shuangji 2, Yueyou 14, Minhua 9, Zhanhua 82, Shanyou 250, Longhua 243, Heyou 11, Pearl Red, Yuanhua 8, Baisha 1016, Quanhua 551, Huaguanwang, Qinglan 8, Huayu 8, Huayu 16, Zhonghua 4, and other 26 varieties, accounting for 23.42% of the tested varieties. Although it has been unclear how the deficiency of 35.5 kDa subunits affects the functional properties of peanut proteins, some research showed that the functional properties (such as solubility, foamability, gelation, thermal coherence, and emulsibility) of plant protein were closely related to the molecular weight distribution, size/composition of subunit, dissociation/polymerization property of subunit, amount of disulfide bond and its thermal stability, and hydrophilicity and hydrophobicity of plant protein during processing (Yang et al. 2001). Therefore, it could be inferred that the deficiency of 35.5 kDa subunits was certain to affect the functional properties of peanut protein.

There were significant differences in the thickness of strips and shade of dyeing in Fig. 2, Appendix 4, which indicated that there were significant differences in the content of each subunit. The statistical analysis (Table 2.11) showed that the component in arachin with the maximum variance coefficient (62.14%) was 35.5 kDa subunit with significant differences among varieties; the variation coefficient of relative content of 40.5 kDa subunit was 16.38 % which was only second to that of 35.5 kDa subunit, and the component with the minimum variance coefficient (8.11%) was 23.5 kDa subunit. The component in conarachin with the maximum variance coefficient (19.89%) was 15.5 kDa subunit, and the variation coefficients of the other subunits were more than 10% with significant differences. The content of 23.5 kDa subunits in arachin was much higher than that of the other subunits, and the relative content was $21.97 \pm 1.78\%$. The content of 61 kDa subunits in conarachin was much higher than that of the other subunits, and the relative content was $18.82 \pm 2.52\%$.

Utsumi and Kinsella (1985a, b) found that the acidic subunit As-III was more important than As-IV in 11S protein during the formation of soybean protein gel; three subunits in 7S protein were involved in the formation of gel, the β subunit in 7S globulin and basic subunit in 11S globulin in the soybean protein isolate gel interacted with each other selectively and affected the gelation of SPI, and the acidic subunit in 11S protein played an important role in the formation of gel network structure. Tay (2004) and Cheng Cuilin et al. (Cheng et al. 2006) found that the subunits (α′, α, and β) were positively correlated with emulsibility, while the subunit $A_{1, 2, 4}$ and subunit β were negatively correlated with emulsibility. Liu et al. (2008) analyzed the SPI prepared by four protein subunit variation types of soybean varieties, and the results showed that the deficiency of single subunit in 11S component did not affect the solubility, emulsibility, emulsifying stability, and

thermal stability of soybean protein significantly, and the significant reduction or deficiency of 11S component content could improve the emulsibility and emulsifying stability of soy protein. Salleh et al. (2004) researched the impacts of deficiency of α and α′ subunits in 7S globulin on soybean protein gel. It was found that the influence relations of components on the gel hardness were deficient α′ subunit>7S whole subunit>deficient α subunit under the same conditions. It is a good point to cultivate special soybean varieties for food with peculiar 11S and 7S protein component contents and subunit germplasm for the research of protein subunit based on molecular genetics, combined with food science research of effect of soybean protein subunits on its functions. Since the 1990s, in the research of soybean protein subunit composition and its processing characteristics, it has gotten more and more attention to change the subunit composition of soybean protein by some ways to obtain the soybean varieties that lack some subunits so as to make these varieties become the special soybean raw materials suitable for processing need characteristics, while there has been no report on the impacts of deficiency of peanut protein subunits on functional properties of protein until now. Therefore, the research on the relationship between the deficiency of different protein component subunits and protein functions will be the emphasis of the further research of this team. This research will provide important basis for the improvement of quality and functional properties of peanut protein and cultivation of peanut varieties with different subunit types.

3.2.4 Analysis of Relative Contents of Protein Component and Subunit (Near-Infrared Spectroscopy)

3.2.4.1 Near-Infrared Spectrum Data

1. Near-infrared characteristic spectrum

   Analyze the relationship between various absorption peaks and absorption groups and see Sect. 3.2.2.3 (1).

2. Analysis of main components of near-infrared spectrum data

   Analyze the differences in near-infrared spectrum data of various varieties by using the main component analysis method and see Sect. 3.2.2.3 (2).

3. Preprocessing of near-infrared spectrum data

   Preprocess the near-infrared spectrum data by using the second-derivative analysis method and see Sect. 3.2.2.3 (3).

3.2.4.2 Near-Infrared Prediction Model

Seventy-four varieties were randomly selected as the modeling sample set from the 111 varieties in Table 2.1, 37 varieties were selected as the modeling validation sample set, the model was established by using PCA and PLS, and the internal cross validation and external validation were conducted to verify the model reliability. See the specific method in 2.2.2.3 (4). The internal cross validation and external validation results of NIRS prediction model are shown in Table 2.12. The scatter diagram of predicted values and true values of three kinds of protein components (arachin, conarachin, and conarachin I) through external validation of 37 varieties is shown in Fig. 2.8. The data in the table and figure showed that the established model was reliable.

3.2.5 Analysis of Fatty Acid Content (Gas Chromatography)

Zhang (2012) determined the composition and contents of fatty acids in 45 peanut varieties in Table 2.1. The results are shown in Table 2.13. There were 13 major fatty acids in peanut, including myristic acid (C14:0), palmitic acid (C16:0), heptadecanoic acid (C17:0), stearic acid (C18:0), arachidic acid (C20:0), behenic acid (C22:0), lignoceric acid (C24:0), palmitoleic acid (C16:1), heptadecenoic acid (C17:1), oleic acid (C18:1), arachidonic acid (C20:1), linoleic acid (C18:2), and linolenic acid (C18:3). Through the calculation by the means, the contents of 13 fatty acids in peanuts were sorted from high to low: C18:1 (37.70%), C18:2 (34.21%), C16:0 (12.37%), C18:0 (3.63%), C18:3 (2.20%), C22:0 (1.77%), C16:1 (1.43%), C20:0 (1.10%), C20:1 (0.70%), C24:0 (0.65%), C17:0 (0.07%), C14:0 (0.03%), and C17:1 (0.03%). Oleic acid and linoleic acid are two fatty acids with high contents in peanuts, and they determine the quality of peanuts and their products to a great extent. Compared with other vegetable oils, the peanut oil has a unique long-chain fatty acid (C20–C24). Among the 45 peanut varieties tested, the long-chain fatty acids content accounted for 2.20–5.83% of the total fatty acid component content. Some research pointed out that the degree of impact of oxidation on long-chain fatty acids was higher than that of short-chain fatty acids, so the unique long-chain fatty acid components in peanut oil were also the causes for oxidative deterioration (Zhang and Wang 2010; Nelson 1997).

The contents and variation coefficients of saturated fatty acids (SFA), unsaturated fatty acids (UFA), polyunsaturated fatty acids (PUFA), monounsaturated fatty acids (MUFA), and other fatty acids in different peanut varieties were analyzed. The results are shown in Table 2.14. Through the calculation by the mean, the contents of SFA, UFA, PUFA, and MUFA in peanuts were 19.63%, 76.28%, 36.41%, and 39.87%, respectively, which indicated that unsaturated fatty acid was the main component in peanuts and accounted for 76% of the total fatty acid content, so the storability of peanut and its products was poor and they were easy to be oxidized. The SFA in peanuts was mainly oriented by palmitic acid (C16:0) with an average content of 12.37%; the variety with the highest content of palmitic acid

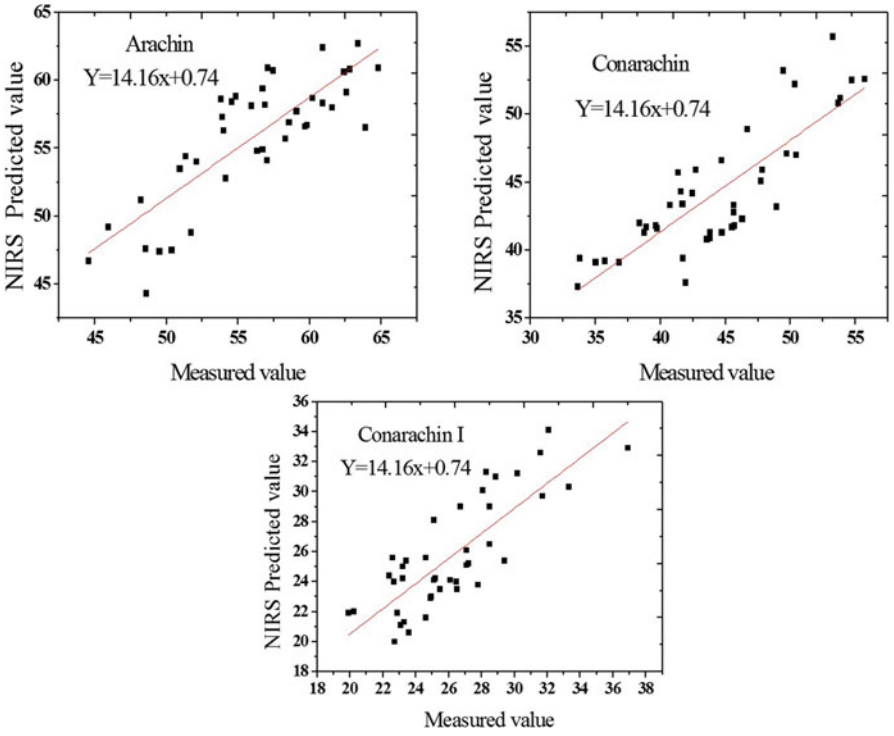


Fig. 2.8 Scatter diagram of true values and predicted values of peanut protein component content

was Fenghua 3 with a content of 15.40%, and the variety with the lowest content was Shanhua 7 with a content of 10.10% and variation coefficient of 8.30%. The variation range of UFA was 64.13–80.05%, and the mean was 76.28%; the varieties with the highest and lowest contents of UFA were Colorful Peanut and Black Peanut; UFA was oriented by oleic acid and linoleic acid, the varieties with the highest and lowest contents of oleic acid content were Kainong 37 (46.90%) and Yueyou 86 (30.50%) with the variation coefficient of 11.35%, and the varieties with the highest and lowest contents of linoleic acid were Zhonghua 8 (40.30%) and Shanhua 7 (24.30%) with the variation coefficient of 11.18%. The peanuts and their products with high contents of oleic acid were storable, and the peanuts with high contents of linoleic acid had medicinal values (Li et al. 2004; Ma et al. 2009); the variation range of PUFA content was 24.48–42.46% with the mean of 36.41%, and the varieties with the highest and lowest PUFA contents were Fenghua 4 and Shanhua 7. The varieties with high PUFA content had high nutritional value, and the varieties with high UFA content had poor oil oxidative stability (Guo et al. 2010). There were high UFA and PUFA contents in peanuts, so peanut oil had high nutritional value and it was easy to be oxidated.

It could be seen from Table 2.14 that the fatty acid components with more than 10% of average contents in the peanut fatty acid composition included C16:0,

Table 2.12 Predication and validation results of amino acids in peanut

No.	Indicator	Calibration set		Internal cross validation set		External validation					
		R^2	RMSE	R^2	RMSE	RSD	RMSD	SEP	R^2	Bias	Slope
1	Arachin	0.64	0.38	0.59	0.44	0.29	0.37	0.31	0.62	0.06	2.023
2	Conarachin	0.61	0.45	0.57	0.54	0.31	0.43	0.33	0.60	−0.33	2.106
3	Conarachin I	0.66	0.33	0.60	0.42	0.28	0.31	0.28	0.62	0.21	2.319

Table 2.13 Fatty acid contents of peanut varieties (unit:%)

Variety	C14:0	C16:0	C17:0	C18:0	C20:0	C22:0	C24:0	C16:1	C17:1	C18:1	C20:1	C18:2	C18:3	SFA	PUFA	UFA	MUFA
Zhonghua 8	0.04	11.60	0.06	2.80	1.12	2.34	1.13	0.50	0.03	37.00	0.90	40.30	1.20	19.09	41.50	79.93	38.43
Shanhua 7	0.04	10.10	0.13	3.10	1.06	1.04	0.51	3.19	0.22	39.50	0.63	24.30	0.18	15.98	24.48	68.02	43.54
Luhua 11	0.00	11.40	0.08	2.85	0.88	1.21	0.55	1.56	0.05	43.20	0.53	30.50	2.30	16.97	32.80	78.14	45.34
Haihua 1	0.03	12.30	0.08	6.29	1.36	2.25	1.03	0.58	0.05	36.20	0.66	36.30	1.29	23.34	37.59	75.08	37.49
Shuangji 2	0.05	11.80	0.08	3.50	0.94	1.29	0.54	3.46	0.16	32.50	0.48	30.70	5.93	18.2	36.63	73.23	36.60
Shanhua 9	0.04	11.10	0.13	3.24	1.14	1.75	0.69	1.22	0.08	37.70	0.64	36.60	2.55	18.09	39.15	78.79	39.64
Fenghua 5	0.03	12.10	0.06	7.42	1.14	1.92	0.76	0.46	0.03	33.40	0.69	39.40	1.14	23.43	40.54	75.12	34.58
Fenghua 1	0.03	12.00	0.07	2.77	0.98	1.65	0.63	1.16	0.05	37.30	0.65	38.00	2.02	18.13	40.02	79.18	39.16
Fenghua 3	0.02	11.40	0.07	2.37	0.77	1.36	0.30	3.46	0.00	32.90	0.53	32.50	5.60	16.29	38.10	74.99	36.89
Fenghua 4	0.03	12.00	0.07	2.91	0.87	1.45	0.23	1.79	0.00	33.10	0.56	39.40	3.06	17.56	42.46	77.91	35.45
Huayu 19	0.05	11.80	0.08	2.86	1.06	1.54	0.70	0.94	0.04	46.30	0.71	27.60	1.19	18.09	28.79	76.78	47.99
Huayu 20	0.03	12.30	0.08	4.66	1.59	2.40	0.71	0.66	0.02	40.70	0.62	32.40	1.10	21.77	33.50	75.50	42.00
Huayu 22	0.03	12.10	0.08	3.01	1.24	2.21	1.02	0.34	0.03	44.20	0.84	32.50	0.52	19.69	33.02	78.43	45.41
Huayu 23	0.04	11.9	0.08	2.39	1.01	1.85	0.87	0.75	0.05	45.40	0.96	30.60	1.05	18.14	31.65	78.81	47.16
Huayu 28	0.03	12.01	0.04	3.79	1.43	2.27	0.82	0.42	0.03	38.80	0.60	36.30	1.42	20.39	37.72	77.57	39.85
Huayu 31	0.03	12.10	0.08	3.06	1.26	2.07	0.94	0.55	0.03	39.90	0.83	35.70	1.13	19.54	36.83	78.14	41.31
Baisha 1016	0.04	11.90	0.08	4.17	1.52	2.20	0.76	0.50	0.03	40.00	0.70	34.70	0.94	20.67	35.64	76.87	41.23
Bianhua 3	0.00	13.20	0.09	3.10	0.96	1.54	0.63	1.70	0.08	34.50	0.56	36.50	2.80	19.52	39.30	76.14	36.84
White Peanut	0.04	13.10	0.06	4.09	1.13	1.76	0.35	0.6	0.00	35.60	0.44	40.30	0.98	20.53	41.28	77.92	36.64
Yuhua 15	0.03	13.10	0.08	3.70	1.33	1.73	0.60	0.76	0.02	38.40	0.61	35.50	1.21	20.57	36.71	76.50	39.79
Yuhua 9326	0.04	13.40	0.08	3.64	1.17	1.82	0.49	1.03	0.03	35.70	0.64	36.70	1.62	20.64	38.32	75.72	37.40
Yuhua 9327	0.03	12.70	0.08	3.50	1.28	1.84	0.15	1.47	0.01	36.80	0.80	33.90	2.13	19.58	36.03	75.11	39.08

Kainong 30	0.03	13.50	0.08	4.04	1.45	1.95	0.48	0.78	0.03	39.30	0.82	33.80	1.27	21.53	35.07	76.00	40.93
Kainong 37	0.04	11.40	0.08	3.23	1.22	1.97	0.57	0.83	0.03	46.90	0.93	27.70	1.22	18.51	28.92	77.61	48.69
Yuanza 9102	0.04	14.50	0.08	3.97	1.31	1.89	0.54	0.56	0.02	35.20	0.66	38.50	0.73	22.33	39.23	75.67	36.44
Black Peanut	0.02	11.40	0.04	15.8	1.39	1.76	0.81	0.58	0.02	31.30	0.65	30.50	1.08	31.22	31.58	64.13	32.55
Xuhua 5	0.04	11.50	0.08	5.51	1.38	2.18	1.07	0.28	0.03	36.90	0.79	38.30	0.66	21.76	38.96	76.96	38.00
Yuanhua 8	0.04	12.00	0.08	4.00	1.30	1.81	0.90	0.56	0.03	38.30	0.70	36.80	1.22	20.13	38.02	77.61	39.59
Xuhua 13	0.03	12.20	0.07	3.73	1.31	1.55	0.60	0.83	0.05	39.20	0.62	35.50	1.65	19.49	37.15	77.85	40.70
Xuhua 14	0.04	13.50	0.06	3.76	1.23	1.72	0.54	1.77	0.02	33.50	0.64	34.80	2.62	20.85	37.42	73.35	35.93
Colorful Peanut	0.02	12.70	0.06	2.55	0.89	1.76	0.58	0.46	0.02	41.30	1.02	36.30	0.95	18.56	37.25	80.05	42.80
Yueyou 14	0.00	11.50	0.06	2.79	1.00	1.92	0.85	2.20	0.00	39.90	0.70	30.40	3.49	18.12	33.89	76.69	42.80
Yueyou 40	0.00	13.70	0.00	1.87	0.67	1.47	0.94	2.70	0.00	35.50	0.84	32.90	3.94	18.65	36.84	75.88	39.04
Yueyou 45	0.00	15.40	0.00	1.90	0.62	1.25	0.00	2.00	0.00	34.40	0.76	37.80	3.15	19.17	40.95	78.11	37.16
Yueyou 86	0.00	14.50	0.11	1.86	0.59	0.98	0.00	4.46	0.00	30.50	0.63	32.20	5.89	18.04	38.09	73.68	35.59
Guihua 771	0.00	12.90	0.08	2.86	1.01	1.84	0.77	1.65	0.00	34.70	0.65	37.50	2.81	19.46	40.31	77.31	37.00
Pearl Red	0.04	11.50	0.08	2.87	0.93	1.73	0.82	2.26	0.00	39.80	0.67	30.90	2.91	17.97	33.81	76.54	42.73
Minhua 9	0.00	13.00	0.09	2.54	1.03	2.07	0.98	1.54	0.00	38.50	0.90	34.60	2.08	19.71	36.68	77.62	40.94
Zhanhua 82	0.00	13.90	0.11	2.71	0.75	1.03	0.36	2.51	0.00	34.30	0.59	35.80	4.26	18.86	40.06	77.46	37.40
Shanyou 250	0.03	12.10	0.07	2.97	1.09	2.61	1.15	0.48	0.00	42.50	0.98	34.10	0.74	20.02	34.84	78.80	43.96
Longhua 243	0.00	11.70	0.08	2.27	0.71	1.03	0.00	5.31	0.00	30.80	0.52	28.40	7.96	15.79	36.36	72.99	36.63
Silihong	0.00	11.50	0.06	2.87	0.94	1.99	0.88	2.20	0.09	31.00	0.89	35.40	4.90	18.24	40.30	74.48	34.18
Heyou 11	0.03	12.80	0.07	3.43	1.10	2.17	0.77	0.51	0.02	37.4	0.73	38.70	1.02	20.37	39.72	78.38	38.66
Jihua 9814	0.04	12.60	0.08	3.50	1.22	1.84	0.59	1.61	0.05	39.90	0.57	30.70	1.78	19.87	32.48	74.61	42.13
034-256-1	0.03	11.40	0.08	3.30	1.32	1.72	0.84	0.99	0.07	46.50	0.81	27.10	1.31	18.69	28.41	76.78	48.37
Mean	0.03	12.37	0.07	3.63	1.10	1.77	0.65	1.43	0.03	37.70	0.70	34.21	2.20	19.63	36.41	76.28	38.09

Table 2.14 Analysis of fatty acid contents of peanut varieties (unit:%)

	Maximum	Minimum	Mean	Variation amplitude	Variation coefficient		Maximum	Minimum	Mean	Variation amplitude	Variation coefficient
C14:0	0.05	0.00	0.03	0.05	62.66	C17:1	0.22	0.00	0.03	0.22	124.54
C16:0	15.40	10.10	12.37	5.30	8.30	C18:1	46.90	30.50	37.70	16.40	11.35
C17:0	0.13	0.00	0.07	0.13	32.05	C20:1	1.02	0.44	0.70	0.58	19.88
C18:0	15.80	1.86	3.63	13.94	58.71	C18:2	40.30	24.30	34.21	16.00	11.18
C20:0	1.59	0.59	1.10	1.00	21.98	C18:3	7.96	0.18	2.20	7.78	76.98
C22:0	2.61	0.98	1.77	1.63	21.87	SFA	31.22	15.79	19.63	15.43	12.53
C24:0	1.15	0.00	0.65	1.15	44.49	PUFA	42.46	24.48	36.41	17.98	10.74
C16:1	5.31	0.28	1.43	5.03	80.27	UFA	80.05	64.13	76.28	15.92	3.74
						MUFA	48.69	32.55	39.87	16.14	9.81

Table 2.15 Analysis of main fatty acid composition of peanuts in different provinces

	Variation range/%	Mean/%	Standard deviation	Variation amplitude/%	Variation coefficient/%	Are there significant differences in fatty acid contents of peanuts in different provinces ($P < 0.05$)
C16:0	11.76–13.25	12.60	0.57	1.49	4.50	Yes
C18:1	35.80–38.71	37.19	1.13	2.91	3.04	No
C18:2	33.09–36.34	34.40	1.23	3.11	3.59	No
SFA	18.57–21.60	19.61	1.28	3.03	6.54	No
MUFA	38.71–40.71	39.52	0.77	2.00	1.94	No
PUFA	35.91–37.76	36.85	0.76	1.85	2.05	No
UFA	74.98–77.16	76.37	0.83	2.18	1.08	No

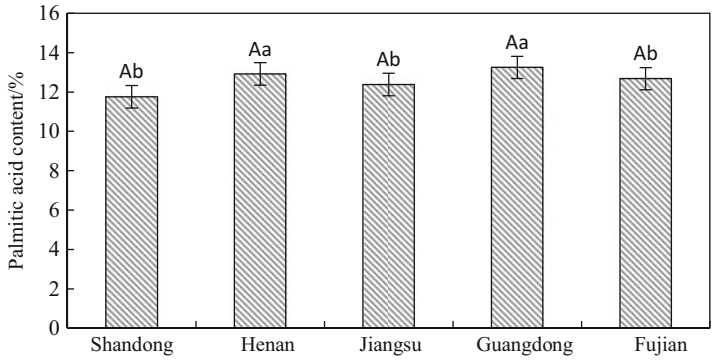


Fig. 2.9 Comparison of palmitic acid contents of peanut varieties in different provinces. Note: a, b, different letters mean significant differences ($P < 0.05$)

C18:1, C18:2 SFA, MUFA, PUFA, and UFA. After the statistical analysis was carried out for above fatty acid contents according to different provinces, it was found that there were differences in the fatty acid contents of peanuts in different provinces. The results are shown in Table 2.15.

In the range of selected peanut varieties, the variation ranges of above fatty acid contents in peanuts in different provinces were C16:0 (11.76–13.25%), C18:1 (35.80–38.71%), C18:2 (33.09–36.34%), SFA (18.57–21.60%), MUFA (38.71–40.71%), PUFA (35.91–37.76%), and UFA (74.98–77.16%). There were significant differences ($P < 0.05$) in the contents of C16:0 in peanuts in different provinces, as shown in Fig. 2.9; the contents of C16:0 in peanuts in Henan and Guangdong were significantly higher than those in Shandong, Jiangsu, and Fujian ($P < 0.05$), and the differences of fatty acid contents in peanuts in other provinces did not reach the significant level.

3.2.6 Analysis of Vitamin E Content (HPLC Method)

3.2.6.1 Standard Curve

The high-performance liquid chromatography (HPLC) was used to analyze the V_E contents in peanuts. Analysis conditions: chromatographic column, Waters C18 (4.6 × 250 mm, 5 μm); mobile phase, methanol-water (98:2, V/V) mixing; UV detection wavelength, 300 nm; injection volume, 20 μL; flow rate, 1.2 mL/min; column temperature, 30 °C.

Accurately weigh a certain amount of α-V_E, γ-V_E, and δ-V_E standard samples, and dissolve and mix them with anhydrous ethanol so that the mass concentrations of α-V_E were 0.1, 0.2, 0.4, 0.6, 0.8, 1.0, and 1.2 mg/mL, that of γ-V_E were 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, and 0.7 mg/mL and that of δ-V_E were 0.01, 0.03, 0.05, 0.07, 0.09, and 0.10 mg/mL, respectively; under the corresponding chromatographic conditions, introduce the samples, respectively, take the peak area X as the abscissa, and take the concentration C (mg/mL) as the ordinate for plotting; the linear regression equations of α-V_E, γ-V_E, and δ-V_E were obtained by the regression fitting of Microsoft Excel software.

Under the determined chromatographic conditions of V_E, the chromatograms of V_E mixed standard samples are shown in Fig. 2.10 and the linear regression equations are shown in Table 2.16.

3.2.6.2 Sample Determination

Zhang (2012) determined the V_E contents in 45 varieties of peanuts in Table 2.1 (Table 2.17). After oil was extracted from various peanut varieties, 5.00 g of peanut oil was weighed and 30 mL of absolute ethyl alcohol, 10 mL of potassium hydroxide solution (1+1), and 5 mL of 10% ascorbic acid solution were added. After full mixing, the mixture was boiled and refluxed for 60 min. The unsaponifiable compounds were extracted, and the extractives were dissolved with 2 mL of ethanol and filtered through a 0.45 μm filter membrane. 20 μL of sample solution was taken and filtered through a 0.45 μm organic phase filter membrane and then HPLC analysis was carried out. The chromatogram of Yuhua 15 is shown in Fig. 2.10b, and the chromatograms of other varieties are shown in Fig. 4, Appendix 4. The retention time and peak area of each chromatographic peak were obtained according to the chromatograms, the quality was determined according to the consistency of retention time, the quantity was determined, and the V_E isomer content in peanut was calculated according to the peak area and standard curve:

$$V_E \text{ isomer content in peanut oil (mg/100g)} = \frac{c \times V}{m} \times 100$$

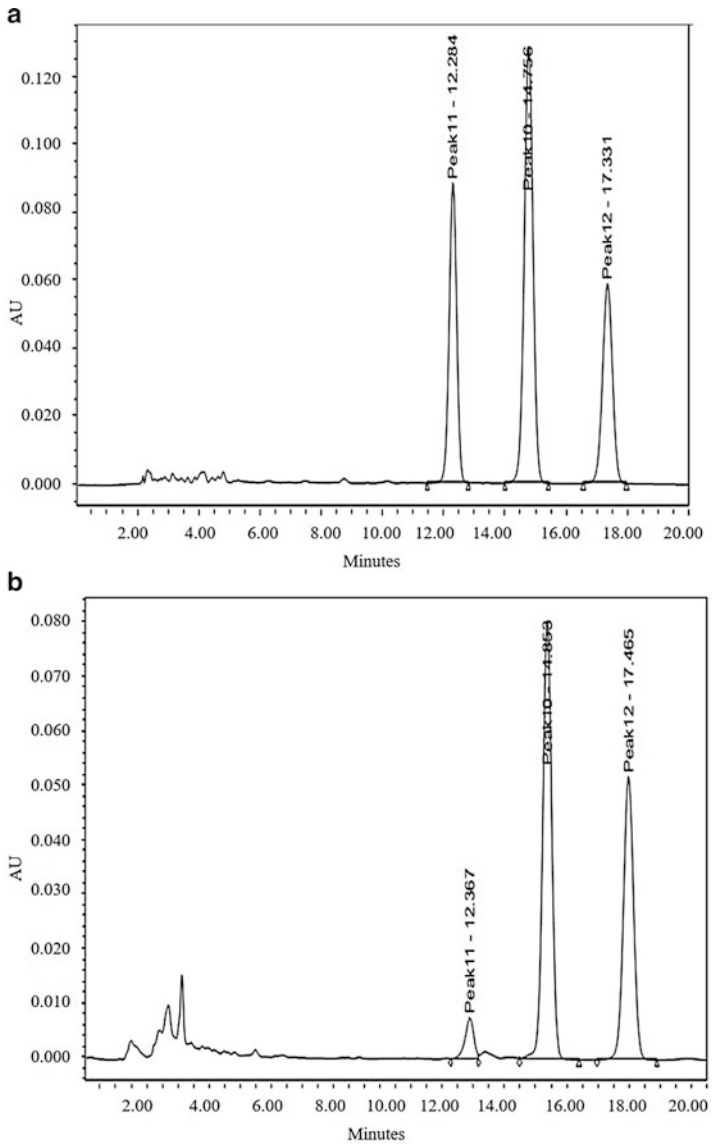


Fig. 2.10 Chromatograms of V_E mixed standard samples and peanut samples. Note: **(a)** standard sample; **(b)** Yuhua 15; 1, δ-V_E; 2, γ-V_E; 3, α-V_E

Table 2.16 V_E linear regression equation

Standard sample	Linear regression equation	Linear range	R^2
α-V_E	$C = 3 \times 10^{-7} \times +0.089$	0.10–1.2 mg/mL	0.994
γ-V_E	$C = 10^{-7} \times +0.001$	0.10–0.70 mg/mL	0.997
δ-V_E	$C = 10^{-7} \times +0.002$	0.01–0.10 mg/mL	0.995

Table 2.17 Contents of V_E and its isomers in different peanut varieties (unit: mg/100 g)

	VE			
Variety	α-V_E	γ-V_E	δ-V_E	Total V_E
Zhonghua 8	27.75 ± 0.28	6.74 ± 0.11	0.36 ± 0.01	34.85 ± 0.18
Shanhua 7	16.80 ± 0.42	6.72 ± 0.20	0.63 ± 0.02	24.15 ± 0.25
Luhua 11	22.96 ± 0.27	9.95 ± 0.30	0.82 ± 0.02	33.72 ± 0.58
Haihua 1	20.08 ± 0.06	9.09 ± 0.03	0.72 ± 0.03	29.88 ± 0.11
Shuangji 2	19.73 ± 0.24	5.89 ± 0.11	0.46 ± 0.02	26.08 ± 0.37
Shanhua 9	16.65 ± 0.28	7.25 ± 0.07	0.50 ± 0.15	24.40 ± 0.21
Fenghua 5	18.13 ± 0.03	5.71 ± 0.04	0.36 ± 0.01	24.20 ± 0.02
Fenghua 1	22.35 ± 0.28	7.41 ± 0.07	0.49 ± 0.07	30.25 ± 0.14
Fenghua 3	19.25 ± 0.35	6.25 ± 0.08	0.41 ± 0.00	25.91 ± 0.27
Fenghua 4	9.36 ± 0.10	7.61 ± 0.03	0.57 ± 0.01	17.54 ± 0.08
Huayu 19	23.34 ± 0.27	8.53 ± 0.06	0.80 ± 0.04	32.67 ± 0.17
Huayu 20	17.67 ± 0.11	6.52 ± 0.04	0.69 ± 0.06	24.87 ± 0.01
Huayu 22	25.25 ± 0.04	9.73 ± 0.01	0.86 ± 0.00	35.92 ± 0.05
Huayu 23	12.16 ± 0.23	4.88 ± 0.14	0.43 ± 0.01	17.47 ± 0.38
Huayu 28	14.75 ± 0.34	4.19 ± 0.06	0.34 ± 0.01	19.28 ± 0.27
Huayu 31	15.09 ± 0.13	6.69 ± 0.17	0.50 ± 0.04	22.28 ± 0.09
Baisha 1016	21.06 ± 0.24	9.49 ± 0.07	0.76 ± 0.02	31.31 ± 0.19
Bianhua 3	19.47 ± 0.01	4.02 ± 0.06	0.29 ± 0.02	23.78 ± 0.06
White Peanut	23.73 ± 0.20	16.93 ± 0.03	0.97 ± 0.02	41.63 ± 0.19
Yuhua 15	21.10 ± 0.21	6.00 ± 0.16	0.62 ± 0.01	27.71 ± 0.36
Yuhua 9326	14.33 ± 0.01	3.47 ± 0.06	0.33 ± 0.01	18.13 ± 0.03
Yuhua 9327	16.00 ± 0.20	4.74 ± 0.04	0.50 ± 0.08	21.24 ± 0.07
Kainong 30	33.98 ± 0.11	6.84 ± 0.07	0.46 ± 0.01	41.28 ± 0.03
Kainong 37	28.28 ± 0.03	9.00 ± 0.08	0.61 ± 0.02	37.89 ± 0.13
Yuanza 9102	27.72 ± 0.10	13.59 ± 0.06	1.30 ± 0.01	42.61 ± 0.04
Black Peanut	14.78 ± 0.28	6.16 ± 0.07	0.41 ± 0.06	21.35 ± 0.42
Xuhua 5	15.42 ± 0.34	5.15 ± 0.06	0.36 ± 0.04	20.93 ± 0.44
Yuanhua 8	20.73 ± 0.24	7.73 ± 0.10	0.57 ± 0.02	29.03 ± 0.16
Xuhua 13	13.61 ± 0.27	4.55 ± 0.06	0.39 ± 0.03	18.55 ± 0.36
Xuhua 14	18.74 ± 0.04	8.03 ± 0.01	0.73 ± 0.10	27.50 ± 0.05
Colorful Peanut	13.52 ± 0.08	9.70 ± 0.20	0.56 ± 0.00	23.78 ± 0.28
Yueyou 14	26.82 ± 0.42	5.73 ± 0.06	0.45 ± 0.06	33.00 ± 0.54
Yueyou 40	24.88 ± 0.41	6.87 ± 0.01	0.58 ± 0.01	32.33 ± 0.43
Yueyou 45	25.50 ± 0.06	9.73 ± 0.06	0.62 ± 0.02	35.85 ± 0.13
Yueyou 86	26.61 ± 0.01	9.41 ± 0.03	0.60 ± 0.10	36.62 ± 0.14
Guihua 771	20.08 ± 0.11	5.08 ± 0.04	0.40 ± 0.02	25.56 ± 0.17
Pearl Red	23.45 ± 0.07	4.29 ± 0.17	0.36 ± 0.02	28.10 ± 0.12
Minhua 9	24.21 ± 0.14	5.71 ± 0.07	0.45 ± 0.02	30.37 ± 0.23
Zhanhua 82	24.00 ± 0.35	6.45 ± 0.08	0.52 ± 0.03	30.97 ± 0.47
Shanyou 250	19.84 ± 0.16	3.72 ± 0.06	0.35 ± 0.01	23.91 ± 0.11
Longhua 243	15.82 ± 0.47	2.88 ± 0.13	0.26 ± 0.01	18.96 ± 0.58

(continued)

Table 2.17 (continued)

Variety	VE			
	α-V_E	γ-V_E	δ-V_E	Total V_E
Silihong	16.76 ± 0.31	6.33 ± 0.23	0.33 ± 0.02	23.42 ± 0.10
Heyou 11	29.07 ± 0.14	7.38 ± 0.07	0.52 ± 0.01	36.97 ± 0.22
Jihua 9814	17.71 ± 0.11	4.78 ± 0.06	0.40 ± 0.01	22.89 ± 0.15
034-256-1	18.57 ± 0.16	5.95 ± 0.03	0.48 ± 0.03	25.00 ± 0.15

c is the content of vitamin E (mg/mL) found on the standard curve, *V* is the concentrated and constant volume of sample (mL), and *m* is the sample mass (g).

There were mainly three V_E isomers (α-V_E, γ-V_E, and δ-V_E) in peanuts. The content of α-V_E was the highest and accounted for 73% of the total V_E content calculated according to the mean, followed by the content of γ-VE which accounted for 25% of the total V_E, and the content of δ-V_E was the lowest and accounted for 2% of the total V_E, which were consistent with the research results of Yang et al. (2009a) and Huang et al. (2001). The physiological activity order of V_E isomers in vivo was δ-V_E<γ-V_E<α-V_E (Kan 2002), so the physiological functions of different peanut varieties might be different if the contents and proportions of V_E and its isomers in different peanut varieties were different.

The maximums, minimums, means, variation amplitudes, and variation coefficients of contents of total vitamin E and its isomers in peanuts were analyzed. The results are shown in Table 2.18. In the 45 peanut varieties, the total V_E content was in the range of 17.47–42.61 mg/100 g and the mean was 27.87 mg/100 g; the variety with the highest V_E content was "Yuanza 9102" and the variety with the lowest V_E content was "Huayu 23"; the α-V_E content was in the range of 9.36–33.98 mg/100 g and the mean was 20.38 mg/100 g; the variety with the highest α-V_E content was "Kainong 30" and the variety with the lowest α-V_E content was "Fenghua 4"; the γ-V_E content was in the range of 2.88–16.93 mg/100 g and the mean was 6.95 mg/100 g; the variety with the highest γ-V_E content was "White Peanut" and the variety with the lowest γ-VE content was "Longhua 243"; the δ-V_E content was in the range of 0.26–1.30 mg/100 g and the mean was 0.54 mg/100 g; the variety with the highest δ-V_E content was "Yuanza 9102" and the variety with the lowest δ-V_E content was "Longhua 243." The variation coefficients of total V_E and α- V_E, γ- V_E, and δ- V_E contents in different peanut varieties were 24.46%, 25.55%, 37.60%, and 37.38%, respectively. The variation coefficients of contents of V_E and its isomers in peanut varieties were large, which could provide the basis for the production of functional peanut products and selection of high-quality varieties.

Statistical analysis was carried out for the contents of V_E and its isomers in different peanut varieties by provincial sources (Fig. 2.11, Table 2.19). In the range of selected peanut varieties, the variation range of α-V_E contents in peanuts in different provinces was 16.40–24.56 mg/100 g, the order of contents from high to low was Guangdong > Henan> Fujian> Shandong> Jiangsu, and the α-V_E content in peanuts in Guangdong was significantly higher than that in peanuts in Jiangsu ($P < 0.01$); the variation range of γ-V_E content was 4.69–7.86 mg/100 g, the order of contents from high to low was Fujian>Guangdong>Jiangsu>Shandong>Henan, and

Table 2.18 Variation analysis of contents of V_E and its isomers in different peanut varieties (unit: %)

Endogenous antioxidant	Maximum	Minimum	Mean	Variation amplitude	Variation coefficient
α-V_E	33.98	9.36	20.38	24.62	25.55
γ-V_E	16.93	2.88	6.95	14.05	37.60
δ-V_E	1.30	0.26	0.54	1.04	37.38
Total V_E	42.61	17.47	27.87	25.14	24.46

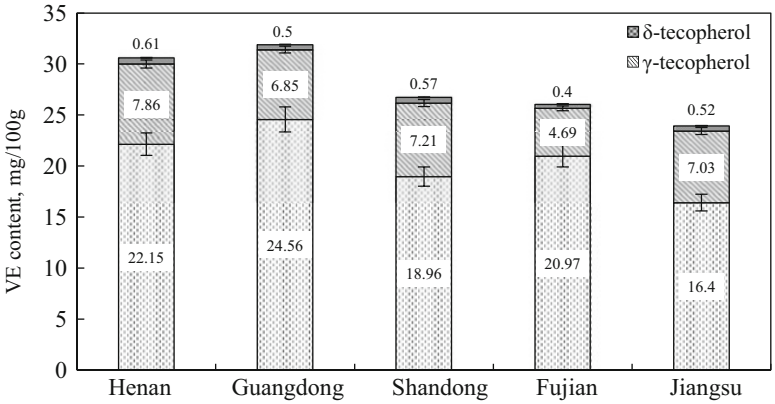


Fig. 2.11 Statistical analysis of contents of V_E and its isomers of peanut varieties in different provinces

Table 2.19 Statistical analysis of contents of V_E and its isomers in peanuts in different provinces

	Shandong	Henan	Jiangsu	Guangdong	Fujian
Total V_E	Aa	Aa	Aa	Aa	Aa
α-V_E	ABab	ABab	Bb	Aa	ABab
γ-V_E	Aa	Aa	Aa	Aa	Aa
δ-V_E	Aa	Aa	Aa	Aa	Aa

Note: A, B: different letters mean highly significant differences ($P < 0.01$); a, b: different letters mean significant differences ($P < 0.05$)

there was no significant difference in the γ-V_E content in peanuts in different provinces ($P < 0.05$); the variation range of δ-V_E content was 0.40–0.61 mg/100 g, the order of contents from high to low was Fujian>Guangdong>Jiangsu>Shandong>Henan, and there was no significant difference in the δ-V_E content in peanuts in different provinces ($P < 0.05$); the variation range of total V_E content was 31.91–23.96 mg/100 g, the order of contents from high to low was Guangdong>Henan>Shandong>Fujian>Jiangsu, and there was no significant difference in the total V_E content in peanuts in different provinces ($P < 0.05$).

In the isomers of V_E, the physiological activity in vivo of α-V_E was the strongest and the oil antioxidant ability of γ-V_E and γ-V_E was the strongest (Kan 2002). In the above five provinces, the α-V_E content in peanuts in Guangdong was the highest and the γ-V_E and δ-V_E contents in peanuts in Fujian were the highest. Therefore, it could be inferred that the varieties with high α-V_E contents could be selected from Guangdong peanut varieties as the varieties with physiological activity and high V_E content in vivo, and the varieties with high γ-V_E and δ- V_E contents could be selected from Fujian peanut varieties as the varieties with oil antioxidant ability and high V_E content.

3.2.7 Analysis of Sterol and Squalene Contents (HPLC Method)

3.2.7.1 Standard Curve

The contents of phytosterol and squalene in peanuts were analyzed by using the high-performance liquid chromatography (HPLC). Analysis conditions: chromatographic column,, Waters SunFire C18 (4.6 × 250 mm, 5 μm); mobile phase: acetonitrile/water (90:10, v/v), mixing and degassing; UV detection wavelength. 210 nm; injection volume, 20 μL; flow rate, 1.5 mL/min; column temperature, 30 °C. A certain amount of stigmasterol, campesterol, and β-sitosterol standard samples were accurately weighed and dissolved and mixed with anhydrous ethanol, so that the mass concentrations of campesterol were 0.2, 0.6, 0.8, 1.0, and 1.2 mg/mL, that of stigmasterol were 0.05, 0.15, 0.25, 0.40, and 0.50 mg/mL and that of β-sitosterol were 0.5, 1.0, 1.5, 2.0, and 3.0 mg/mL, respectively. Under the corresponding chromatographic conditions, introduce the samples, respectively, take the peak area X as the abscissa, and take the concentration C (mg/mL) as the ordinate for plotting; the linear regression equations of stigmasterol, campesterol, and β-sitosterol were obtained by the regression fitting of Microsoft Excel software. Under the determined chromatographic conditions of phytosterol and squalene, the chromatograms of phytosterol and squalene mixing standard samples are shown in Fig. 2.12 and the linear regression equations are shown in Table 2.20.

3.2.7.2 Sample Determination

Zhang et al. (2012) tested the phytosterol and squalene contents in 45 different peanut varieties in Table 2.1 simultaneously by using the high-performance liquid chromatography (Table 2.21). 5.00 g of peanut oil was accurately weighed, and 30 mL of absolute ethyl alcohol, 10 mL of potassium hydroxide solution (1 + 1), and 5 mL of 10% ascorbic acid solution were added. After mixing, the mixture was boiled and refluxed for 60 min. The unsaponifiable compounds were extracted, and the extractives were dissolved with 2 mL of ethanol and filtered through a 0.45 μm of filter membrane. 20 μL of sample solution was taken and filtered through a 0.45 μm organic phase filter membrane and then the HPLC

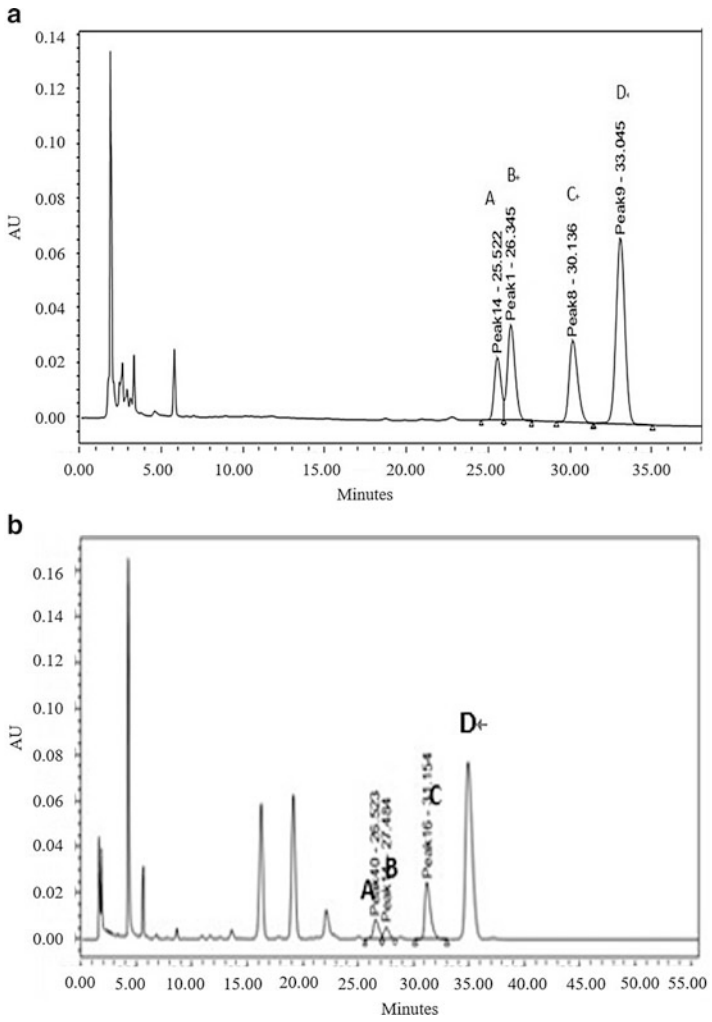


Fig. 2.12 Chromatograms of phytosterol and squalene mixing standard samples and peanut samples. Note: (**a**) standard sample; (**b**) Luhua 11; *A*, campesterol; *B*, stigmasterol; *C*, β-Sitosterol; *D*, squalene

Table 2.20 Linear regression equations of phytosterol and squalene

Standard sample	Linear regression equation	Linear range	R^2
Campesterol	$C = 4 \times 10^{-7} - 0.412$	0.20–1.20 mg/mL	0.996
Stigmasterol	$C = 3 \times 10^{-7} - 0.138$	0.05–0.50 mg/mL	0.997
β-Sitosterol	$C = 3 \times 10^{-7} - 0.119$	0.50–3.00 mg/mL	0.998
Squalene	$C = 10^{-8} + 0.003$	0.10–0.50 mg/mL	1.000

Table 2.21 Phytosterol and squalene contents of different peanut varieties. Unit: mg/100 g

	Phytosterol			Squalene
Variety	Stigmasterol	Campesterol	β-sitosterol	Squalene
Zhonghua 8	15.32 ± 0.33	30.60 ± 1.92	100.05 ± 0.07	7.60 ± 0.01
Shanhua 7	3.14 ± 0.24	22.04 ± 0.40	73.76 ± 0.18	8.59 ± 0.08
Luhua 11	15.42 ± 1.06	32.91 ± 1.16	101.23 ± 0.49	12.81 ± 0.06
Haihua 1	12.76 ± 0.95	28.68 ± 0.07	96.89 ± 0.86	13.56 ± 0.07
Shuangji 2	11.18 ± 0.59	18.54 ± 0.03	67.62 ± 0.66	6.68 ± 0.28
Shanhua 9	8.11 ± 0.88	17.92 ± 1.17	74.01 ± 0.20	9.56 ± 0.28
Fenghua 5	10.58 ± 1.29	19.04 ± 0.53	80.08 ± 1.63	9.25 ± 0.35
Fenghua 1	13.48 ± 0.57	27.61 ± 0.64	100.63 ± 0.20	10.63 ± 0.55
Fenghua 3	6.25 ± 1.03	20.48 ± 0.66	73.65 ± 0.18	9.67 ± 0.55
Fenghua 4	11.79 ± 1.29	27.82 ± 0.59	89.23 ± 0.06	6.40 ± 0.17
Huayu 19	17.41 ± 0.17	34.98 ± 0.14	100.65 ± 0.48	8.98 ± 0.30
Huayu 20	9.03 ± 0.04	20.29 ± 0.11	58.65 ± 0.93	6.09 ± 0.13
Huayu 22	17.38 ± 0.23	37.13 ± 1.06	108.29 ± 0.57	10.68 ± 0.27
Huayu 23	3.18 ± 0.13	4.20 ± 0.16	44.09 ± 0.28	3.77 ± 0.78
Huayu 28	9.11 ± 0.48	21.37 ± 0.18	57.45 ± 0.37	9.27 ± 0.38
Huayu 31	8.17 ± 0.41	16.22 ± 0.57	65.72 ± 0.49	7.61 ± 0.59
Baisha 1016	14.39 ± 0.86	33.21 ± 0.03	77.34 ± 0.08	9.10 ± 0.18
Bianhua 3	9.62 ± 0.88	16.28 ± 0.25	65.44 ± 0.61	7.63 ± 0.10
White Peanut	14.93 ± 1.39	42.53 ± 0.21	87.17 ± 1.19	16.45 ± 0.17
Yuhua 15	15.89 ± 0.01	26.61 ± 0.34	72.93 ± 0.13	9.26 ± 0.21
Yuhua 9326	9.83 ± 0.65	15.31 ± 0.44	60.51 ± 0.48	8.04 ± 0.18
Yuhua 9327	9.23 ± 0.33	19.74 ± 0.45	65.09 ± 0.03	7.70 ± 0.44
Kainong 30	17.16 ± 0.28	44.00 ± 1.47	85.86 ± 1.22	12.71 ± 0.17
Kainong 37	22.62 ± 0.07	48.64 ± 0.04	110.88 ± 0.13	14.35 ± 0.11
Yuanza 9102	17.02 ± 0.08	67.39 ± 0.11	115.70 ± 0.44	13.88 ± 0.13
Black Peanut	7.16 ± 0.06	17.49 ± 0.27	68.40 ± 0.42	10.13 ± 0.23
Xuhua 5	6.16 ± 0.23	11.48 ± 0.75	54.00 ± 0.06	5.80 ± 0.03
Yuanhua 8	2.95 ± 0.81	36.59 ± 1.50	92.64 ± 0.06	8.61 ± 0.04
Xuhua 13	7.66 ± 0.47	10.73 ± 0.91	46.49 ± 0.55	5.71 ± 0.27
Xuhua 14	7.76 ± 0.18	30.74 ± 1.20	75.18 ± 0.38	7.80 ± 0.18
Colorful Peanut	10.25 ± 0.25	17.76 ± 0.44	53.04 ± 0.06	5.28 ± 0.14
Yueyou 14	12.65 ± 1.65	27.48 ± 0.57	87.61 ± 1.12	9.00 ± 0.11
Yueyou 40	8.97 ± 1.09	19.41 ± 0.47	80.03 ± 0.24	12.60 ± 0.04
Yueyou 45	3.42 ± 0.31	26.49 ± 0.71	80.66 ± 0.66	10.96 ± 0.13
Yueyou 86	1.04 ± 0.06	28.29 ± 0.04	78.64 ± 1.53	11.09 ± 0.11
Guihua 771	6.15 ± 0.58	11.78 ± 0.11	48.37 ± 0.01	4.05 ± 0.17
Pearl Red	10.33 ± 0.47	16.53 ± 0.57	55.15 ± 0.14	8.18 ± 0.24
Minhua 9	10.82 ± 0.64	17.18 ± 0.61	68.24 ± 0.33	9.34 ± 0.33
Zhanhua 82	9.43 ± 0.07	18.94 ± 0.98	67.81 ± 0.10	9.59 ± 0.17
Shanyou 250	9.61 ± 0.86	15.60 ± 0.57	69.40 ± 0.28	7.46 ± 0.27
Longhua 243	3.73 ± 0.11	3.89 ± 0.18	38.82 ± 0.33	5.39 ± 0.16

(continued)

Table 2.21 (continued)

Variety	Phytosterol			Squalene
	Stigmasterol	Campesterol	β-sitosterol	Squalene
Silihong	0.31 ± 0.10	14.48 ± 1.17	94.87 ± 0.54	5.39 ± 0.16
Heyou 11	11.12 ± 0.40	28.00 ± 0.64	85.55 ± 0.42	13.09 ± 0.03
Jihua 9814	11.23 ± 0.08	16.72 ± 0.44	52.75 ± 0.81	7.09 ± 0.03
034-256-1	11.03 ± 0.74	21.26 ± 0.41	66.56 ± 0.64	8.00 ± 0.66

analysis was carried out. The retention time and peak area of each chromatographic peak were obtained, the quality was determined according to the consistency of retention time, the quantity was determined, and the phytosterol and squalene contents in peanuts were calculated according to the peak area and standard curve. The chromatogram of Luhua 11 is shown in Fig. 2.16 and the chromatograms of other varieties are shown in Fig. 5, Appendix 4.

Peanut mainly contained β-sitosterol, campesterol, and stigmasterol, and the order of their contents from high to low was β-sitosterol>campesterol>stigmasterol, which were consistent with the research results of Feng Shuyuan (2006), Nelson and Carlos (1995), and Ramakanth et al. (2006). After calculation according to the means, the average contents of these three phytosterols in peanuts were 75.49 mg/100 g, 24.10 mg/100 g, and 10.11 mg/100 g, respectively, and the average content of squalene was 9.00 mg/100 g.

Variation analysis was carried out on the phytosterol and squalene contents in 45 peanut varieties (Table 2.22). It could be seen that the campesterol content was in the range of 3.89–67.39 mg/100 g and the mean was 24.10 mg/100 g; the varieties with the highest and lowest campesterol contents were "Yuanza 9102" and "Longhua 243," respectively; the stigmasterol content was in the range of 0.31–22.62 mg/100 g and the mean was 10.11 mg/100 g; the varieties with the highest and lowest stigmasterol contents were "Kainong 37" and "Silihong," respectively; the β-sitosterol content was in the range of 38.82–115.70 mg/100 g and the mean was 75.49 mg/100 g; the varieties with the highest and lowest β-sitosterol contents were "Yuanza 9102" and "Longhua 243," respectively. The variation coefficients of total phytosterol and campesterol, stigmasterol, and β-sitosterol contents in different peanut varieties were 29.56%, 48.94%, 47.51%, and 24.99%, respectively; the squalene content was in the range of 3.77–16.45 mg/100 g and the mean was 9.00 mg/100 g; the varieties with the highest and lowest squalene contents were "White Peanut" and "Huayu 23," respectively, with the variation coefficient of 31.55%. There were significant differences in the contents of phytosterol components and squalene in peanut varieties, and the variation coefficient was large, which laid a theoretical foundation for development of peanut products with high phytosterols and squalene contents and selection of peanut varieties with high content and quality.

Statistical analysis was carried out on the contents of phytosterol and its isomers of different peanut varieties by provincial sources (Fig. 2.13, Table 2.23). In the range of selected peanut varieties, the variation range of total sterol content in

Table 2.22 Variation analysis of phytosterol and squalene contents of different peanut varieties

Endogenous antioxidant	Maximum/ mg/100 g	Minimum/ mg/100 g	Mean/mg/ 100 g	Variation amplitude	Variation coefficient/%
Stigmasterol	22.62	0.31	10.11	22.31	48.94
Campesterol	67.39	3.89	24.10	63.50	29.56
β-Sitosterol	115.70	38.82	75.49	76.88	47.51
Squalene	16.45	3.77	9.00	12.68	31.55

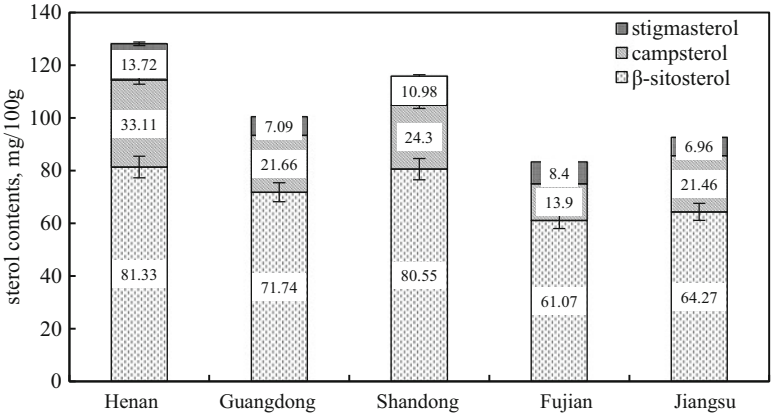


Fig. 2.13 Statistical analysis of phytosterol contents of peanut varieties in different provinces

Table 2.23 Analysis of difference significance of phytosterol contents in peanuts in different provinces

	Shandong	Henan	Jiangsu	Guangdong	Fujian
Stigmasterol	Aab	Aa	Ab	Ab	Ab
Campesterol	ABab	Aa	ABab	ABab	Bb
β-Sitosterol	Aa	Aa	Aa	Aa	Aa
Total sterol	Aab	Aa	Aab	Aab	Ab

Note: A, B, different letters mean highly significant differences ($P < 0.01$); a, b, different letters mean significant differences ($P < 0.05$)

peanuts in different provinces was 83.37–128.16 mg/100 g, the order of contents from high to low was Henan>Shandong>Guangdong>Jiangsu>Fujian, and the total sterol content in peanuts in Henan was significantly higher than that in peanuts in Fujian ($P < 0.05$); the variation range of stigmasterol content was 7.09–13.72 mg/100 g, the order of contents from high to low was Henan>Shandong>Fujian>Guangdong>Jiangsu, and the stigmasterol content in peanuts in Henan was significantly higher than that in peanuts in Jiangsu, Guangdong, and Fujian ($P < 0.05$); the variation range of campesterol content was 13.90–33.11 mg/100 g, the order of contents from high to low was

Henan>Shandong>Guangdong>Jiangsu>Fujian, and the campesterol content in peanuts in Henan was extremely significantly higher than that in peanuts in Fujian ($P < 0.01$); the variation range of β-sitosterol content was 61.07–81.33 mg/100 g, the order of contents from high to low was Henan>Shandong>Guangdong>Jiangsu>Fujian, and there was no significant difference in the β-sitosterol content in peanuts in different provinces ($P < 0.05$).

Phytosterol had several physiological functions such as serum cholesterol reduction, prostate disease prevention, anticancer, anti-inflammatory, immune regulation, and so on, and among the above three kinds of phytosterols (stigmasterol, campesterol, and β-sitosterol), the above physiological functions of β-sitosterol were the strongest (Li et al. 2011). Among the above peanuts in five provinces, the total sterol and β-sitosterol contents in peanuts in Henan were the highest, so it could be inferred that the varieties with high total sterol or β-sitosterol contents could be selected from the peanut varieties in Henan as the raw materials for development of functional peanut products.

The statistical analysis was carried out for the squalene content in different peanut varieties by provincial source (Fig. 2.14). In the range of selected peanut varieties, the variation range of squalene content in peanuts in different provinces was 6.64–11.13 mg/100 g, the order of contents from high to low was Henan>Guangdong>Shandong>Fujian>Jiangsu, and the squalene content in peanuts in Henan was significantly higher than that in peanuts in Jiangsu ($P < 0.01$). Squalene was a kind of natural antioxidant that could prevent the peroxidation of unsaturated fatty acids, protect cells from damage of free radical, and enhance cellular immune systems in cells (Qiao et al. 2011). The squalene content in peanuts in Henan was the highest among the five provinces, so it could be initially inferred that the varieties with high squalene content could be selected from the peanut varieties in Henan.

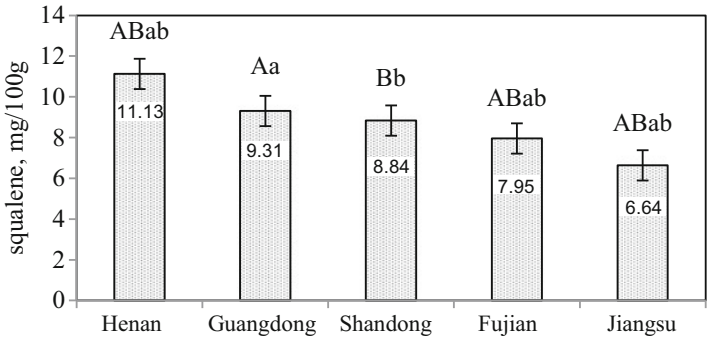


Fig. 2.14 Statistical analysis of squalene content of peanut varieties in different provinces. Note: *A*, *B*: different letters mean highly significant differences ($P < 0.01$); *a*, *b*: different letters mean significant differences ($P < 0.05$)

4 Analysis of Processing Quality

The processing characteristics of peanut varieties or raw materials are closely related to the quality of processed peanut products; if the quality of different varieties or raw materials is different, the quality of their processed products is different and there are no suitable processing varieties or raw materials, and it is difficult to produce high-quality peanut products. Therefore, the processing quality of peanut varieties directly affects the product quality, and it is of great significance to comprehensively analyze the processing quality of peanut varieties or raw materials; research the processing quality testing technologies, methods, and standards; and select the appropriate special varieties for processing for effectively promoting the healthy development of peanut processing industry in China. In this section, based on the summary of domestic and international testing technologies, the normative determination methods were used to conduct analytic determination and statistical determination for the processing quality of peanut varieties in China, and the processing quality characteristics of peanut varieties in China were cleared initially in this book.

4.1 Determination Method

4.1.1 Pure Kernel Rate

1. Domestic standard: GB/T 5499-2008 Determination of pure kernel yield of unhulled oilseeds
2. Foreign standard: There is no standard and the oil seeds are weighed after shelling by shelling machine.

4.1.2 Oil Yield

1. Domestic method: Quality of extracted oil/quality of oil in raw materials
2. Foreign methods: Quality of extracted oil/quality of oil in raw materials

4.1.3 Protein Extraction Rate

1. Domestic method: Quality of extracted protein/quality of protein in raw materials
2. Foreign method: Quality of extracted protein/quality of protein in raw materials

4.1.4 Oleic Acid/Linoleic Acid

1. Domestic standards: GB/T 5009.168-2016 Determination of fatty acids in foods

2. AOAC standard: AOAC Official Method 996.06 Fat (Total, Saturated, and Unsaturated)

4.1.5 Unsaturated Fatty Acids/Saturated Fatty Acids

1. Domestic standards: GB/T 5009.168-2016 Determination of fatty acids in foods
2. AOAC standard: AOAC Official Method 996.06 Fat (Total, Saturated, and Unsaturated)

4.1.6 Relative Contents of Protein Component and Subunit

1. Domestic method: There is no standard and SDS-PAGE is used with optical density analysis currently.
2. Foreign method: There is no standard and SDS-PAGE is used with optical density analysis currently.

4.2 Data Analysis

4.2.1 Pure Kernel Rate, Protein Extraction Rate, and Oil Yield

Through the analysis of pure kernel rate, protein extraction rate, and oil yield of different peanut varieties (Table 2.24), it could be found that there were significant differences in that of different varieties. The pure kernel rate refers to the ratio of kernel and shell of peanut; the greater the value, the higher utilization rate of peanut. In this study, the variation range of pure kernel rate of peanut was large (50.31–79.94%), which indicated that the plumpness of various varieties was different and might affect the properties of peanut and its products. The variation range of protein extraction rate was 59.51–88.97%, which indicated that there were differences in the contents, composition, and properties of protein in different peanut varieties. The variation coefficient of oil yield was 13.80%, which indicated that there were differences in the contents, composition, and properties of fat in different peanut varieties.

Table 2.24 Statistical analysis of pure kernel rate, protein extraction rate, oil yield, and O/L of different peanut varieties

Factor	Variation range	Mean	Variation coefficient/%
Pure kernel rate	50.31–79.94	69.93 ± 5.94	8.50
Oil yield	24.04–54.60	38.25 ± 5.28	13.80
Protein extraction rate	59.51–88.97	74.00 ± 5.78	7.81
O/L	0.84–1.72	1.12 ± 0.07	20.61%

4.2.2 Oleic Acid/Linoleic Acid

After the oleic acid/linoleic acid (O/L) in different tested peanut varieties was analyzed, it was found that there were six varieties with the O/L ratio of more than 1.4; they were Shanhua 7, Luhua 11, Huayu 19, Huayu 23, Kainong 37, and 034-256-1, and their O/L values were 1.63, 1.42, 1.68, 1.48, 1.69, and 1.72, respectively. From the statistical results, it could be seen that the variation range of O/L values of various peanut varieties was 0.84–1.72, the mean was 1.12, the variation coefficient was 20.61% which was large, and the O/L values were widely distributed; O/L was an important indicator to measure the nutritional quality and storage quality of peanuts, and the developed countries had considered the O/L value as one of the main quality indicators of peanut breeding (Ding 2011); from the aspect of storability, the higher the O/L value, the longer the shelf life, the better the storability (Guo et al. 2010); from the aspect of nutritional quality, the lower the O/L, the higher the relative content of linoleic acid, the higher the nutritional value (Wan 2007); if the peanut processing purposes were different, the requirements of O/L value were different; it was required that the O/L value of export peanut was higher than 1.4 (Wan 2007) and the O/L value of fresh peanut was low (Wan 2007; Wu et al. 2008). Therefore, the storable type varieties, nutritional type varieties, and other special varieties for different processing purposes could be selected according to the difference of O/L value.

4.2.3 Unsaturated Fatty Acids/Saturated Fatty Acids

The statistical analysis was carried out for the unsaturated fatty acids/saturated fatty acids (UFA/SFA) and their variation coefficients of different peanut varieties. The results are shown in Tables 2.25 and 2.26. It could be seen that the variation range of UFA/SFA value of peanut was 2.05–4.62 and the mean was 3.94; the varieties with the highest and lowest UFA/SFA values were Longhua 243 and Black Peanut, respectively.

The difference analysis was carried out for UFA/SFA of peanut varieties in different provinces. The results are shown in Table 2.26 and Fig. 2.15. In the range of selected peanut varieties, the UFA/SFA range of peanuts in different provinces was 3.57–4.15, and there were different degrees of differences in the peanuts in different provinces. Through the comparison of UFA/SFA diagrams of peanuts in different provinces, it was found that the UFA/SFA of peanuts in Guangdong and Fujian was significantly higher than that in Henan ($P < 0.05$), and there was no significant difference in UFA/SFA of peanuts in Shandong, Jiangsu, Guangdong, and Fujian.

Table 2.25 UFA/SFA of peanut variety

Variety	UFA/SFA	Variety	UFA/SFA	Variety	UFA/SFA
Zhonghua 8	4.19	Huayu 31	4.00	Colorful Peanut	4.31
Shanhua 7	4.26	Baisha 1016	3.72	Yueyou 14	4.23
Luhua 11	4.60	Bianhua 3	3.90	Yueyou 40	4.07
Haihua 1	3.22	White Peanut	3.80	Yueyou 45	4.07
Shuangji 2	4.02	Yuhua 15	3.72	Yueyou 86	4.08
Shanhua 9	4.36	Yuhua 9326	3.67	Guihua 771	3.97
Fenghua 5	3.21	Yuhua 9327	3.84	Pearl Red	4.26
Fenghua 1	4.37	Kainong 30	3.53	Minhua 9	3.94
Fenghua 3	4.60	Kainong 37	4.19	Zhanhua 82	4.10
Fenghua 4	4.44	Yuanza 9102	3.39	Shanyou 250	3.94
Huayu 19	4.24	Black Peanut	2.05	Longhua 243	4.62
Huayu 20	3.47	Xuhua 5	3.54	Silihong	4.08
Huayu 22	3.98	Yuanhua 8	3.86	Heyou 11	3.85
Huayu 23	4.34	Xuhua 13	3.99	Jihua 9814	3.75
Huayu 28	3.80	Xuhua 14	3.52	034-256-1	4.11
Mean 3.94					

Table 2.26 Statistical analysis of contents of main fatty acid composition of peanuts in different provinces

	Variation range	Mean	Standard deviation	Variation amplitude	Variation coefficient	Are there significant differences in fatty acid contents of peanuts in different provinces ($P < 0.05$)
UFA/SFA	3.57–4.15	3.94	0.24	0.58	6.11	Yes

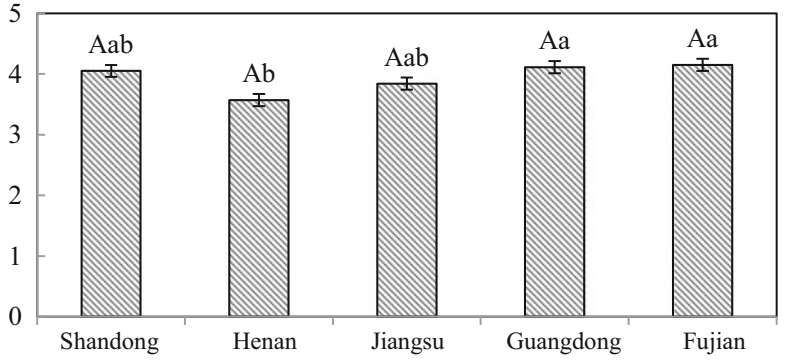


Fig. 2.15 Comparison of UFA/SFA of peanut varieties in different provinces. Note: *a*, *b*: different letters mean significant differences ($P < 0.05$)

4.2.4 Arachin/Conarachin

The types, structures, and contents of various components of peanut protein were closely related to the functional properties of protein. The research showed that arachin/conarachin was an important indicator to measure the functional properties of peanut protein. This team analyzed the contents and proportions of arachin and conarachin in 170 varieties of peanuts by using SDS-PAGE. The results were shown in Table 2.27. It could be seen that the variation coefficients of arachin I and arachin II contents of 170 peanut varieties were large and they were 11.59% and 13.02%, respectively, which indicated that the differences among various varieties were large.

The variation range of ratio of arachin and conarachin was between 0.80 and 1.68 with a mean of 1.24 ± 0.19; there were 85 copies of samples with the ratio higher than the mean, accounting for half of the total number of samples (Table 2.28 and Fig. 2.16). The variation coefficient was 15.23% and exceeded 10%, which indicated that there was a large genetic variation in the protein composition among different peanut varieties.

The ratios of arachin/conarachin of different peanut varieties were different. Among the 170 varieties analyzed, the variety with the highest ratio was Xuhua 5 with the ratio of 1.68 and the variety with the lowest ratio was Luhua 8 with the ratio of 0.80. The research showed that 11S, 7S, and 11S/7S of soybean were closely related to the functional properties, the disulfide bond content of 11S was higher than that of 7S, and the structure of 11S was compact; therefore, the formed gelation hardness of 11S was larger than that of 7S, but the emulsibility and solubility of 7S component were higher than that of 11S component (Song et al. 2010). Saio (1969) reported that the hardness, springiness, and viscosity of tofu gel

Table 2.27 Variation analysis of peanut protein component contents

Subunit	Sample capacity	Variation amplitude (%)	Mean±standard deviation (%)	Variation coefficient (%)
Arachin	170	44.30–62.70	55.00 ± 3.90	7.08
Conarachin I	170	20.00–34.10	25.79 ± 2.99	11.59
Conarachin II	170	13.40–25.70	19.21 ± 2.50	13.02
Conarachin I and II	170	37.30–55.70	45.00 ± 3.90	8.67

Table 2.28 Ratio of arachin and conarachin

Ratio of arachin/conarachin	Number of varieties	Average ratio	Proportion/%
<1.0	19	0.90	11.18
1.0–1.2	47	1.12	27.65
1.2–1.4	72	1.29	42.35
1.4–1.6	26	1.47	15.29
>1.6	6	1.65	3.53

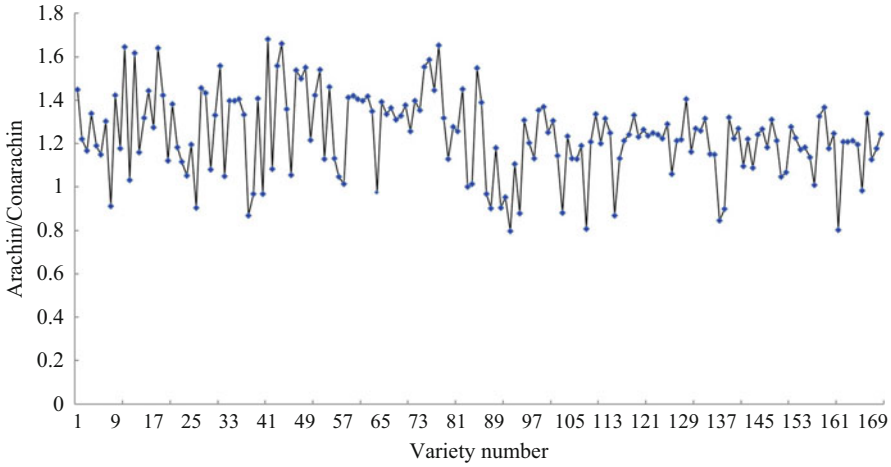


Fig. 2.16 Distribution diagram of ratios of arachin and conarachin

made from 11S globulin were significantly better than that of tofu made from 7S globulin. The research conducted by Arrese et al. (1991) showed that the 11S/7S ratio of soybean protein was closely related to the thermal gel of protein. There was a significant positive correlation between 11S/7S and hardness of tofu gel ($r = 0.86$) (Cheng et al. 2006; Mujoo et al. 2003). The difference in arachin/conarachin ration among different peanut varieties was large, which provided the basis for selecting the peanut varieties with high-quality functional properties.

5 Correlation in Quality Characteristic Indicators of Peanut Raw Materials

The sensory quality, physicochemical and nutritional quality, processing characteristics, and other quality properties of peanut varieties or raw materials are formed constantly in the growth and development process of peanuts. The formation of quality in the planting process is determined by genetic factors and nongenetic factors. The genetic factors refer to the genetic modes and genetic characteristics that determine the characteristics of varieties, and the nongenetic factors refer to all factors other than genetic factors, such as ecological and environmental conditions, cultivation measures, mineral nutrients, and other factors. The quality property of peanuts after harvest has been determined, and the analysis shows that there is a certain correlation between the quality characteristics of different peanut varieties or raw materials. The research on the correlation between the quality characteristics of peanut raw materials is of practical guiding significance to deep understanding of processing characteristics of raw materials, mutual influence in processing and their interaction rules, and further production of high-quality processed peanut products.

5.1 Correlation in Sensory Quality

The analysis of correlation among peanut sensory quality indicators was carried out (Table 1, Appendix 3), and it was found that the peanut fruit shape (the order was hockey shape<hump shape<bead shape<common shape<bee waist shape<gourd shape<cocoon shape<axe shape) was significantly positively correlated with the grain shape (the order was elliptical shape<triangular shape<peach shape <conical shape<cylindrical shape) ($r = 0.438$), which indicated that the peanut fruit shape was closely related to the grain shape and the change of fruit shape would affect the change of grain shape significantly. At the same time, the results showed that the grain shape (the order was oval shape<triangle shape<peach shape<conical shape<cylindrical shape) was negatively correlated with the hundred kernel weight ($r = -0.464$), there was a highly significant positive correlation between the hundred fruit weight and hundred kernel weight ($r = 0.923$), and there was a positive correlation between the hundred kernel weight and pure kernel rate ($r = 0.422$), which indicated that the higher the hundred kernel weight, the higher the pure kernel rate.

5.2 Correlation in Physicochemical and Nutritional Quality

The research and analysis of physicochemical and nutritional quality indicators of different peanut varieties (Table 1, Appendix 3) showed that there were different correlations among the indicators. There was a significant negative correlation between crude fat and crude protein which was consistent with the results of Jiang and Duan (1992) and Liu and Liang (1993), which indicated that it was feasible to cultivate the peanut varieties with high protein or high fat. There were significant negative correlations between crude fat and many amino acids, such as total amino acid ($r = -0.563$), aspartic acid ($r = -0.513$), threonine ($r = -0.488$), serine ($r = -0.538$), glutamate ($r = -0.556$), glycine ($r = -0.550$), cystine ($r = -0.573$), valine ($r = -0.613$), isoleucine ($r = -0.436$), leucine ($r = -0.497$), tyrosine ($r = -0.514$), phenylalanine ($r = -0.545$), lysine ($r = -0.594$), and arginine ($r = -0.403$), which indicated that the reduction of fat content could increase the relative content of amino acids. This conclusion provided a basis for the cultivation of new peanut varieties with high amino acid content. There were significant positive correlations between the crude protein and total amino acid ($r = 0.408$), aspartic acid ($r = 0.409$), proline ($r = 0.676$), valine ($r = 0.431$), isoleucine ($r = 0.536$), leucine ($r = 0.449$), histidine ($r = 0.528$), and arginine ($r = 0.533$), and the result was consistent with that of Yang et al. (2009b), which indicated that the content and quality of peanut protein could be improved by increasing the content of certain amino acid.

The correlation analysis of relative contents of peanut protein components and their subunits (Table 1, Appendix 3) showed that there were correlations among

arachin, conarachin, and arachin/conarachin and various components and their subunits and between the various subunits basically. There were highly significant negative correlations between arachin and conarachin ($r = -0.995$), conarachin I ($r = -0.745$), and arachin II ($r = -0.648$) with interaction. There was a highly significant positive correlation between arachin and 35.5 kDa ($r = 0.860$), and there were highly significant negative correlations between arachin and 40.5 kDa ($r = -0.552$), 37.5 kDa ($r = -0.463$), 18 kDa ($r = -0.687$), and 17 kDa ($r = -0.568$). There were highly significant positive correlations between conarachin and 40.5 kDa ($r = 0.555$), 37.5 kDa ($r = 0.467$), 18 kDa ($r = 0.704$), and 17 kDa ($r = 0.543$), and there was a highly significant negative correlation between conarachin and 35.5 kDa. There were highly significant negative correlations between conarachin I and arachin/conarachin ($r = -0.744$) and 35.5 kDa ($r = -0.567$), and there were highly significant positive correlations between conarachin I and 18 kDa ($r = 0.742$), 17 kDa ($r = 0.790$), and 15.5 kDa ($r = 0.580$). There were highly significant negative correlations between conarachin II and arachin/conarachin ($r = -0.648$) and 35.5 kDa ($r = -0.650$); there were highly significant negative correlations between arachin/conarachin and 40.5 kDa ($r = -0.527$), 37.5 kDa ($r = -0.467$), 18 kDa ($r = -0.697$), and 17 kDa ($r = -0.555$); and there was a highly significant positive correlation between arachin/conarachin and 35.5 kDa ($r = 0.848$). There were highly significant positive correlations between 40.5 and 37.5 kDa ($r = 0.535$) and 18 kDa ($r = 0.494$) and there was a highly significant negative correlation between 40.5 and 35.5 kDa ($r = -0.740$). There was a highly significant positive correlation between 37.5 and 18 kDa and there was a highly significant negative correlation between 37.5 kDa and pure kernel rate ($r = -0.461$). There were highly significant negative correlations between 35.5 and 18 kDa ($r = -0.677$) and 17 kDa ($r = -0.477$). The correlation analysis showed that the main components of peanut protein and their subunits interacted with each other. If the content of any one of the components was changed, the content of other components might be affected directly or indirectly. Therefore, the arachin components could be improved by increasing the content of 35.5 kDa subunit so as to improve arachin/conarachin; the contents of conarachin and corresponding subunits could also be increased by reducing the content of 35.5 kDa subunit, which provided a theoretical reference for the selection and breeding of peanut varieties with high arachin or conarachin content.

As for fatty acid composition, there were highly significant correlations ($P < 0.01$) between oleic acid and linoleic acid ($r = -0.41$), UFA and oleic acid ($r = 0.43$) and linoleic acid ($r = 0.46$), MUFA and oleic acid ($r = 0.97$) and linoleic acid ($r = -0.57$). PUFA and oleic acid ($r = -0.66$) and linoleic acid ($r = 0.90$), MUFA and UFA/SFA ($r = 0.40$), and O/L and MUFA ($r = 0.92$), PUFA ($r = -0.93$), oleic acid ($r = 0.84$), and linoleic acid ($r = -0.83$). There was a highly significant negative correlation between oleic acid and linoleic acid, which indicated that the peanuts with high oleic acid content often had low linoleic acid content. Jiang and Duan (1993) found that there was a highly significant negative correlation between oleic acid and linoleic acid in multigrain type, pearl type, Longsheng type, common type, and intermediate type peanuts by analyzing the

Table 2.29 Correlation of peanut fatty acid composition

	Linoleic acid	UFA	SFA	UFA/SFA	MUFA	PUFA	O/L
Oleic acid	−0.41**	0.43**	−0.18	0.24	0.97**	−0.66**	0.84**
Linoleic acid		0.46**	0.26	−0.20	−0.57**	0.90**	−0.83**
UFA			−0.4**	0.51**	0.36 *	0.38*	−0.02
SFA				−0.97 **	−0.36*	0.07	−0.28
UFA/SFA					0.40**	−0.02	0.27
MUFA						−0.73**	0.92**
PUFA							−0.93**
O/L							1.00

Note: **Means highly significant correlation ($P < 0.01$); *means significant correlation ($P < 0.05$)

correlation between oleic acid and linoleic acid contents in different botany types of peanuts, and the correlation coefficients were −0.713, −0.942, −0.979, −0.944, and −0.929, respectively, as shown in Table 2.29.

For endogenous antioxidant of peanuts (Table 2.30), there was a significant or highly significant positive correlation ($P < 0.05$ or $P < 0.01$) between α, γ, and δ-V_E and stigmasterol, campesterol, β-sitosterol, and squalene, there was a highly significant positive correlation ($P < 0.01$, $r = 0.85$) between γ-V_E and δ-V_E, and the correlation coefficient was the highest, followed by that between campesterol and β-sitosterol ($P < 0.01$, $r = 0.82$), which indicated that the content of one of the unsaponifiable components in peanuts, such as V_E, phytosterols, and squalene, would increase or decrease with the increasing or decreasing of the content of the other component and provide a basis for the selection of peanut varieties with high bioactive substances.

5.3 *Correlation in Processing Quality*

The research and analysis of processing quality indicators of different peanut varieties (Table 2.31) showed that the correlation coefficient among various indicators was low, which remained to be further researched.

5.4 *Correlation Among Sensory Quality, Physicochemical and Nutritional Quality, and Processing Quality*

Some research showed that there were correlations among the sensory quality, physicochemical quality, processing characteristics, and other quality properties of peanut varieties or raw materials. There was a positive correlation ($r = 0.661$) between crude fat and fruit shape (the order is hockey shape<hump shape<bead shape<common shape<bee waist shape<gourd shape<cocoon shape<axe shape). The same trend was also shown in soybeans, which meant that the varieties with

Table 2.30 Correlation among VE, phytosterol, and squalene in peanut

	γ	δ	Stigmasterol	Campesterol	β-sitosterol	Squalene
α	0.36*	0.32*	0.48**	0.64**	0.59**	0.67**
γ		0.85**	0.37*	0.76**	0.63**	0.67**
δ			0.44**	0.78**	0.60**	0.58**
Stigmasterol				0.64**	0.54**	0.52**
Campesterol					0.82**	0.73**
β-Sitosterol						0.67**
Squalene						1.00

Note: **Means highly significant correlation; *means significant correlation

Table 2.31 Analysis of correlation in processing quality of peanut

	Arachin/conarachin	Protein extraction rate	Oil yield	Kernel yield	Ratio of oleic acid and linoleic acid
Arachin/conarachin	1.000				
Protein extraction rate	0.185	1.000			
Oil yield	−0.084	−0.146	1.000		
Kernel yield	0.267	0.032	0.239	1.000	
Ratio of oleic acid and linoleic acid	−0.091	−0.108	−0.132	0.088	1.000

small soybean seeds generally had high fat content, therefore, pay attention to the selection and breeding of small-grain varieties when selecting and cultivating the varieties with high fat content (Zhou et al. 2008). There was a negative correlation between crude protein and fruit shape (the order was hockey shape<hump shape<bead shape<common shape<bee waist shape<gourd shape<cocoon shape<axe shape), and there was a positive correlation ($r = 0.747$) between grain shape and crude fat (the order of grain shape was cylindrical shape>peach shape>conical shape>oval shape); there was a negative correlation ($r = -0.2719$) between grain shape (the order was oval shape<triangle shape<peach shape<conical shape<cylindrical shape) and crude protein, and there was a positive correlation ($r = 0.516$) between crude protein and 37.5 kDa; the research results of this team were consistent with those of Mozingo et al. (1988). There was a positive correlation ($r = 0.514$) between crude fiber and protein extraction rate; the high crude fiber content might be more conducive to the dissolution of protein so that the protein extraction rate would be increased. There was a significant positive correlation between 23.5 kDa and protein extraction rate ($r = 0.456$). The above analysis showed that there were different degrees of correlations among the sensory quality, physicochemical and nutritional quality, and processing quality of peanut; an indicator might cause or restrict the change of several indicators, and thus the change trend of one indicator might affect the change trend of other indicators. The research in this aspect will be described in the following chapters.

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