



# Study on nutritional quality and volatile aroma compounds of the stir-fried shredded potatoes

Yuci Zhao<sup>1,2</sup> · Xiaohua Wang<sup>3</sup> · Wanjun Liao<sup>4</sup> · Dan Xu<sup>1,2</sup>  · Gang Liu<sup>1,2</sup>

Accepted: 21 February 2022 / Published online: 24 May 2022  
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## Abstract

In this study, we systematically analyzed the nutritional quality and volatile aroma compounds of stir-fried shredded potatoes, which had higher dietary fiber and calcium contents than deep fat-fried and shallow-fried potatoes and an excellent essential amino acid composition. Compared with deep fat-fried and shallow-fried potatoes, stir-fried shredded potatoes had a lower fat content. Stir frying led to a reduction in protein, starch, mineral (P, Mg, K), and vitamin contents. Incomplete gelatinization of starch granules in stir-fried shredded potatoes may have resulted in less loss of resistant starch. Moreover, this processing method, which is used in Chinese households, effectively reduced the glycoalkaloid concentration. Further volatile aroma compound analysis identified a total of 74 volatile aroma compounds, including hydrocarbons, aromatic hydrocarbons, alcohols, aldehydes, ketones, esters, furans, ethers, and other compounds. 4-methyloctane, hexanal,  $\alpha$ -phellandrene,  $\gamma$ -terpinene, *o*-cymene, diallyl disulfide, and linalool were the main flavor-contributing components.

**Keywords** Stir-fried shredded potatoes · Nutrition · Starch · Glycoalkaloids · Volatile aroma compounds

## Introduction

Potatoes are an important crop worldwide and are a substantial component of the global population's diet. Potatoes are rich in carbohydrates, vitamins, minerals, dietary fiber, and other bioactive compounds, and their rich nutrients can greatly improve dietary nutrition (Jayanty et al., 2019). Potatoes are fat-free, and their proteins possess excellent biological value (Zhou et al., 2019). It is well recognized that potatoes are advantageous due to the good balance

of amino acids (Murniece et al., 2011), such as lysine and threonine (Camire et al., 2009). In addition, potatoes are a well-known source of minerals and vitamins (Navarre et al., 2016).

Potatoes contain a large amount of starch, and the content of resistant starch (RS) in fresh potatoes is higher than that in cooked potatoes. RS has a wide range of effects on human health. RS cannot be digested and absorbed in the small intestine but can be fermented by intestinal microorganisms in the large intestine to produce short-chain fatty acids and CO<sub>2</sub>. It can maintain the acidic environment of the intestine and promote the discharge of toxins. It can also effectively prevent constipation, enteritis, hemorrhoids, and colon cancer. Consuming foods with high RS content can also reduce postprandial glycemia, decrease the content of plasma cholesterol and triglycerides, and promote the absorption of calcium, magnesium, zinc, and other minerals (Choi et al., 2013).

Steroidal glycoalkaloids are important biologically active substances in potato tubers.  $\alpha$ -Chaconine and  $\alpha$ -solanine are the main glycoalkaloids in potatoes (Friedman, 2015). Glycoalkaloids have an effect on the flavor of potatoes and are regarded as toxic to humans if the concentration exceeds 200 mg/kg of the fresh weight of potato tubers (Sinden et al., 2006).

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✉ Dan Xu  
danxu@licp.cas.cn

✉ Gang Liu  
gangliu@licp.cas.cn

<sup>1</sup> Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, No.18, Tianshui Middle Road, 730000 Lanzhou, People's Republic of China

<sup>2</sup> University of Chinese Academy of Sciences, 100049 Beijing, China

<sup>3</sup> Gansu Food Inspection and Research Institute, 730000 Lanzhou, China

<sup>4</sup> Department of Public Health, Medical College, Qinghai University, 810008 Xining, China

In China, stir-fried shredded potatoes are very common, whether at the family table or in hotels (Fig. 1). Stir-fried shredded potatoes have become increasingly popular and significantly contribute to the food cultures of many civilizations throughout the world. Some hot spices, such as chili peppers, garlic, ginger, and mustard, are commonly used in many foods to stimulate the senses with exotic flavors and burning sensations. In addition to enhancing the pleasure of eating, some of these species provide nutritional value and have antioxidant and antibacterial properties (Reinbach et al., 2010).

Chili pepper is the most common ingredient in China. It is rich in nutrients, has a unique taste and can not only increase appetite but also prevent cancer and other diseases

(Rotsachakul et al., 2008). Therefore, stir-fried shredded potatoes are considered the perfect combination of potato and chili pepper with a pleasant flavor. Each cooking procedure results in a unique profile of flavor compounds. However, to date, the flavor of stir-fried shredded potatoes has not been studied.

This study addresses common cooking methods and assesses the contents of simple nutrients and volatile aroma compounds in stir-fried shredded potatoes. We aim to provide a reliable basis for estimating the daily dietary nutrient intake of residents in China. The results will provide a theoretical basis and practical guidance for potato cooking.



**Fig. 1** Photograph of the stir-fried shredded potatoes

## Materials and methods

### Materials

Dingshu 3 potatoes (a potato variety that is round with a white peel and flesh and slightly rough skin) and Dingshu 4 potatoes (a potato variety that is oblate with a yellow peel and flesh and slightly rough skin) are two different potato varieties. They were obtained from the Dingxi Research Institute of Agriculture and Sciences in Gansu Province, China. Commercial potatoes for which the potato cultivar was not clearly indicated were purchased from a local market.  $\alpha$ -Chaconine and  $\alpha$ -solanine were purchased from ChromaDex (Irvine, CA, USA). High-performance liquid chromatography (HPLC)-grade acetonitrile, tetrahydrofuran, analytical-grade potassium dihydrogen phosphate ( $\text{KH}_2\text{PO}_4$ ), and ammonium hydroxide ( $\text{NH}_4\text{OH}$ ) were obtained from commercial sources.

### Preparation of stir-fried shredded potatoes

After peeling, the potatoes were shredded with a food processor. Then, the samples were placed in a colander rinsed thoroughly with cold standing water (1 L) for 5–7 s to remove the starch. Then, the washed potatoes were placed in boiling water for approximately 30 s. After that, they were immediately dried. Each shredded potato sample (200 g) was stirred with 40 g of heated oil ( $150 \pm 5$  °C), for 30 s until translucent. The contents of nutritional components, including protein, fat, dietary fiber, minerals, vitamins, starch, resistant starch, amino acids, and glycoalkaloids, were measured in uncooked samples and cooked stir-fried shredded potatoes.

### Analysis of nutritional components

The protein content was determined according to the Chinese National Standard Method (Chinese National Standard GB 5009.5–2016). Proteins are decomposed under catalytic heating condition, and the ammonia combines with sulfuric acid to form ammonium sulfate. The protein content was determined using a Kjeldahl Instrument, which determines the nitrogen content of the sample, and the protein content was calculated by multiplying the nitrogen content by a factor of 6.25 (Gong et al., 2020; Liao et al., 2020; Wang et al., 2020; Yao et al., 2020; El-Dakar et al., 2021; Luo et al., 2021).

The content of fat in this study was determined according to the Chinese National Standard Method (Chinese National Standard GB 5009.6–2016). The content of fat was determined using the Soxhlet method (Jiang et al., 2020; Wang et

al., 2020; El-Dakar et al., 2021). Briefly, 3 g of the sample was subjected to Soxhlet extraction with petroleum ether (60 °C for 10 h). After solvent evaporation at  $100 \pm 5$  °C for 1 h, the sample was left to cool and weighed to determine the fat content.

The levels of total dietary fiber (TDF), insoluble dietary fiber (IDF), and soluble dietary fiber (SDF) were determined according to the Chinese National Standard Method (Chinese National Standard GB 5009.88–2014). The samples were gelatinized with heat-stable  $\alpha$ -amylase (95–100 °C, 35 min) and then enzymatically digested with protease (60 °C, 30 min), to solubilize the protein. Then, the samples were filtered, washed (with water, 95% ethanol, and acetone), dried, and weighed to determine the insoluble fiber content. After that, four volumes of 95% ethanol (60 °C) were added to the filtrate and the water washings. Then, the precipitates were filtered and washed twice with 95% ethanol and acetone. After that, the residues (soluble fiber) were dried and weighed. Total dietary fiber content was determined by summing the insoluble dietary fiber and soluble dietary fiber contents (Wang et al., 2020; Lyu et al., 2021).

The mineral contents, including phosphorus (P), calcium (Ca), magnesium (Mg), and potassium (K) contents, were measured and analyzed based on the Chinese National Standard Methods GB 5009.87–2016, GB 5009.92–2016, GB 5009.241–2017, and GB 5009.91–2017. The samples were digested with concentrated  $\text{HNO}_3$  (5 mL) and  $\text{HClO}_4$  (1 mL) in an oven at 100 °C for 6 h. The digested samples were transferred to volumetric flasks (100 mL), diluted, filtered through Whatman No. 541 filter paper, and then transferred to plastic bottles (50 mL) for the determination of mineral content using an atomic absorption spectrophotometer (Yao et al., 2020; Zhao et al., 2020).

The vitamin C content was titrated with 2,6-dichloroindophenol according to the method described in Chinese National Standard GB 5009.86–2016 (Ouyang et al., 2021; Tang et al., 2021). The acid leachate of the sample containing ascorbic acid is carried out to redox titration by blue alkaline dye (2,6-dichloroindophenol). The contents of vitamin  $\text{B}_6$  and vitamin  $\text{B}_1$  were determined according to the Chinese National Standard Method GB 5009.154–2016 and GB 5009.84–2016, respectively. For the determination of vitamin  $\text{B}_6$ , the sample is hydrolyzed and then enzymatically hydrolyzed by amylase. Adjust the pH of the above sample solution to  $1.7 \pm 0.1$  with hydrochloric acid solution. Then adjust the pH to  $4.5 \pm 0.1$  with sodium hydroxide solution. HPLC system equipped with a fluorescence detector was used in the detection. Separation was carried out using a ZORBAX SB-Aq  $\text{C}_{18}$  column ( $4.6 \times 150$  mm, 5  $\mu\text{m}$ ). The mobile phase consisted of a solution of methanol/sodium octane sulfonate/triethylamine. The flow rate was 1 mL/

min, the excitation wavelength was 293 nm, and the emission wavelength was 395 nm.

For the determination of vitamin B<sub>1</sub>, the sample was hydrolyzed at constant temperature in dilute hydrochloric acid medium, neutralized, and then enzymatically hydrolyzed. The hydrolyzate solution was derivatized with alkaline potassium ferricyanide solution and extracted with *n*-butanol.

HPLC system equipped with a fluorescence detector was used in the detection. Separation was carried out using a ZORBAX SB-Aq C<sub>18</sub> column (4.6×250 mm, 5 μm). The mobile phase consisted of a solution of 0.05 mol/L sodium acetate/methanol (65:35). The flow rate was 0.8 mL/min, the excitation wavelength was 375 nm, and the emission wavelength was 435 nm (Guo et al., 2021; Xu et al., 2021).

The content of starch was measured according to the Chinese National Standard Method GB 5009.9–2016 (the second method). Starch content was determined using an enzymatic method (Jiang et al., 2020; Luo et al., 2021). After the sample is removed from fat and soluble sugar, the starch is hydrolyzed into small molecular sugars with amylase, and then hydrolyzed into monosaccharides with hydrochloric acid. Finally, it is determined by reducing sugars and converted into starch content.

Resistant starch content was analyzed according to the AOAC Official Method 2002.02 (Resistant Starch in Starch and Plant Materials, Enzymatic Digestion) (Artavia et al., 2020; Park et al., 2020; Ren et al., 2020). Samples were incubated with pancreatic α-amylase and amyloglucosidase (AMG) for 16 h at 37 °C to remove the non-RS fractions. The residues were collected and hydrolyzed with the addition of 2 M KOH with continuous stirring. The acetate buffer (1.2 M) was then added into the hydrolysate to adjust the pH before incubation with 0.1 mL of AMG at 50 °C for 30 min. 0.1 mL aliquot of the supernatant and 3 mL of glucose oxidase/peroxidase reagent were mixed at 50 °C for 20 min. The glucose content was measured spectrophotometrically at the absorbance of 510 nm. The content of RS was calculated accordingly with the method provided by the assay kit.

Amino acid levels in this study were determined according to the Chinese National Standard Method (Chinese National Standard GB 5009.124–2016). The sample was dissolved in 6 N HCl (8 mL), poured into a hydrolysis tube with a screw cap, and then hydrolyzed under nitrogen gas in an oven at 120 °C for 22 h. The extracted samples were dissolved in 4.8 mL 10 M NaOH to neutralize them for acid hydrolysis. After dilution to a known volume and filtration, the hydrolysates (400 μL) were injected into an HPLC column. Detection of amino acids was carried out at wavelength 570 nm and 440 nm, respectively (Liao et al., 2020).

## Scanning electron microscopy (SEM)

Before being analyzed, the samples were coated with gold and examined using scanning electron microscopy under an acceleration voltage of 20 kV at magnifications of 200× and 500×. A JSM-5600LV instrument was used.

## Analysis of glycoalkaloids by HPLC

All the samples (peeled uncooked samples and cooked stir-fried shredded potatoes) were ground in a ceramic mortar. The samples (20 g) were extracted with 40 mL of 5% acetic acid and then ultrasonicated for 10 min at room temperature. The other treatment steps were the same as those described in a study by Friedman et al. (2003). The glycoalkaloids were precipitated with concentrated NH<sub>4</sub>OH, dissolved in 1,000 μL of a mixture of acetonitrile/tetrahydrofuran/20 mM KH<sub>2</sub>PO<sub>4</sub> (pH=4.9) (50:30:20, v/v/v), and centrifuged at 18,000×g for 10 min at 4 °C. The supernatant was used for HPLC.

The method used in this study employed an Inertsil NH<sub>2</sub> column (5 μm, 4.0 mm × 250 mm; GL Science Inc., Tokyo, Japan). The mobile phase was acetonitrile/20 mM KH<sub>2</sub>PO<sub>4</sub> (pH=4.9) (80:20, v/v). The flow rate was 1 mL/min at a column temperature of 22 °C. HPLC was conducted with a model 2998 photodiode array detector set at 208 and 340 nm. The solvents were filtered through a 0.22 μm membrane filter and degassed with an ultrasonic bath before use.

In order to eliminate the influence of ingredients (salt, garlic, peppers, etc.) on potato nutritional components, ingredients are not added to the cooked stir-fried shredded potatoes in all the nutrient composition detection including protein, fat, dietary fiber, minerals, vitamins, starch, resistant starch, amino acids and glycoalkaloids. These ingredients are only added in the determination of volatile aroma components.

## TD-GC/MS analysis

After peeling, the potatoes were shredded with a food processor. Then, the samples were placed in a colander rinsed thoroughly with cold standing water (1 L) for 5–7 s to remove the starch. Then, the washed potatoes were placed in boiling water for approximately 30 s. After that, they were immediately dried. Each shredded potato sample (200 g) and additional ingredients (0.4 g peppercorns, 5 g garlic, and 2.6 g red peppers) were added to 40 g of heated oil (150 ± 5 °C) and stirred for 30 s until fragrant. Immediately before the end of cooking, 5 g green onions and 1 g salt were added, and the potatoes were stirred until translucent.

The detection method described by Zeng et al. (2019) was used with some modifications: 10 g of each sample was put in a clean and tasteless glass bottle (100 ml), pre-ged stainless-steel TD tubes (90 mm × 6.4 mm, filled with Tenax-TA) were used to collect the volatile flavor compounds at room temperature, and the flow-rate of the air-sampling pump (SHC model, Shandong Success Hydrogen Energy Co. Ltd., Jinan, China) was set at 150 ml/min for 2 h. After sampling, the TD tubes were capped and analyzed by TD-GC/MS immediately.

Desorption of the volatile flavor compounds retained on the adsorbent tubes was carried out with a Colintech Auto TD A thermal desorption system (Chengdu Colin Analysis Technology Co., LTD, Chengdu, China). Tube desorption was performed at 180 °C for 5 min followed by 280 °C for 8 min, the sample injection time was 60 s, and the condenser temperature was −30 °C. The transfer line and valve temperatures were 200 °C and 150 °C, respectively. Pure helium gas (99.999% purity) and air were used as the carrier and driver, respectively, and the pressure of the carrier gas was 90 kPa.

Separation and detection of the volatile flavor compounds were performed in a 7890 A gas chromatograph and a 5975 C inert MSD with Triple-Axis Detector mass spectrometer from Agilent Technologies Ltd., using an HP-Innowax capillary column (60 m × 0.25 mm i.d. × 0.5 μm, Agilent, Wilmington, USA). The oven temperature was initially held at 60 °C for 1 min for GC, increased to 170 °C at a rate of 2 °C/min, and kept at that temperature for 20 min. Pure helium gas (99.999% purity) was used as the carrier at a flow rate of 1.2 mL/min, and the injection port temperature was 320 °C. A constant column head pressure of 10 psi and a split ratio of 2:1 were used.

Mass spectrometer detection was performed in electron ionization mode (EI) at an electron impact energy of 70 eV and scan mode with a m/z interval from 25 to 550. The transfer line and MS source temperatures were 250 °C and 230 °C, respectively. Compounds were tentatively identified by comparing the mass spectra to those found in the NIST Mass Spectral Search Program (NIST 11 version mass spectral database (National Institute of Standards and Technology, Washington, DC, USA)), and all spectra were calibrated using perfluorotributylamine (PFTBA) for external calibration.

### Statistical analysis

One-way analysis of variance was performed using SPSS software, and a significance level of 95% ( $p < 0.05$ ) by Duncan’s multiple range test was used. All experiments were carried out in triplicate, and average values and standard deviation errors are reported.

## Results and discussion

### Nutritional properties

#### Protein

The chemical characteristics of stir-fried shredded potatoes pf the three varieties before and after cooking are summarized in Table 1. The protein contents of Dingshu 3 potatoes, Dingshu 4 potatoes, and market potatoes before cooking were 2.21, 1.78, and 2.45 (g/100 g), respectively. The market variety showed the highest protein content,

**Table 1** Chemical composition of stir-fried shredded potatoes before and after cooking on a fresh-weight basis. Different lowercase letters indicate significant differences ( $p < 0.05$ ) between the different samples.

Composition	Cultivars					
	Dingshu 3		Dingshu 4		Market	
	Before	After	Before	After	Before	After
Protein (g/100 g)	2.21 ± 0.04 b	1.38 ± 0.08 d	1.78 ± 0.05 c	1.44 ± 0.16 d	2.45 ± 0.21 a	1.47 ± 0.14 d
Fat (g/100 g)	0.10 ± 0.02 d	1.60 ± 0.10 c	0.10 ± 0.02 d	2.80 ± 0.27 a	0.10 ± 0.02 d	2.10 ± 0.12 b
Total dietary fiber (g/100 g)	2.58 ± 0.13 d	6.55 ± 0.22 a	2.56 ± 0.23 d	4.76 ± 0.33 c	1.19 ± 0.11 e	5.64 ± 0.20 b
Insoluble dietary fiber (g/100 g)	1.72 ± 0.08 d	4.56 ± 0.23 a	1.19 ± 0.12 e	2.64 ± 0.11 b	0.66 ± 0.10 f	2.00 ± 0.12 c
Soluble dietary fiber (g/100 g)	0.86 ± 0.08 d	1.99 ± 0.11 b	1.37 ± 0.16 c	2.12 ± 0.17 b	0.53 ± 0.06 e	3.64 ± 0.14 a
Phosphorus (P) mg/100 g	54.40 ± 0.07 b	40.00 ± 2.72 c	58.60 ± 1.68 a	36.80 ± 2.86 c	53.30 ± 1.74 b	37.50 ± 2.01 c
Calcium (Ca) mg/kg	7.26 ± 0.07 d	41.00 ± 1.39 b	7.79 ± 0.26 d	52.70 ± 2.26 a	6.44 ± 0.14 d	36.60 ± 2.26 c
Magnesium (Mg) mg/kg	89.70 ± 0.82 a	55.50 ± 2.33 e	78.30 ± 1.73 b	53.40 ± 1.76 e	72.80 ± 2.24 c	64.10 ± 2.81 d
Potassium (K) mg/100 g	227.00 ± 2.35 a	74.50 ± 2.46 de	199.00 ± 6.00 b	75.50 ± 2.86 d	175.00 ± 4.54 c	68.00 ± 2.75 e
vitamin C mg/100 g	10.00 ± 0.95 c	7.00 ± 0.35 d	8.00 ± 0.92 d	7.00 ± 0.26 d	25.00 ± 1.11 a	20.00 ± 1.26 b
vitamin B <sub>6</sub> mg/100 g	0.450 ± 0.019 a	0.281 ± 0.036 b	0.482 ± 0.018 a	0.310 ± 0.022 b	0.281 ± 0.009 b	0.231 ± 0.012 c
vitamin B <sub>1</sub> mg/100 g	0.101 ± 0.012 a	0.041 ± 0.006 c	0.088 ± 0.015 a	0.032 ± 0.002 c	0.065 ± 0.010 b	0.031 ± 0.003 c
Starch (g/100 g)	15.60 ± 0.62 b	13.80 ± 0.52 c	12.70 ± 0.75 cd	11.80 ± 1.31 d	19.20 ± 0.44 a	17.90 ± 0.70 a
Resistant starch (g/100 g)	9.60 ± 0.26 b	2.90 ± 0.17 e	7.80 ± 0.44 c	2.40 ± 0.26 e	12.40 ± 0.70 a	1.90 ± 0.26 d

and Dingshu 4 potatoes possessed the lowest content. As shown in Table 1, the protein content of the three varieties was decreased to some extent after the potatoes were stir-fried. The degree of protein loss was different among the three varieties; the percentage of protein lost from the market variety was as high as 40.00%, that of Dingshu 3 potatoes was 37.56%, and that of Dingshu 4 potatoes was only 19.10%. It is possible that most of the protein is degraded under high-temperature conditions, and temperature and time are the two important factors of protein degradation (McDonald et al., 2000). Cooking can also cause protein denaturation in potatoes. Studies have shown that frying and baking are more likely to cause protein denaturation than boiling and steaming (Seo et al., 2014). In general, the protein content of potatoes after cooking is the same as that of fresh potatoes and may be even higher because the proportion of dry matter increases after water evaporation (Mcgill et al., 2013; Murniece et al., 2011). The method of stir frying used to cook the shredded potatoes in this study led to a reduction in the protein content of the potatoes.

Table 2 displays the amino acid compositions of stir-fried shredded potatoes before and after cooking. Glutamic acid and aspartic acid were present at the highest levels among nonessential amino acid levels in potatoes, while leucine, arginine, valine, and lysine were present at the highest levels among essential amino acids (Table 2). In this study,

significant differences were noted when evaluating the amino acid content of stir-fried shredded potatoes before and after cooking. There were few differences between varieties (Table 2). It is worth noting that there were no significant differences in leucine, valine, lysine, and tyrosine contents before and after cooking, and the ratio of essential amino acids in stir-fried shredded potatoes was significantly enhanced compared with that in uncooked potatoes (Table 2). There is a high essential amino acid content in potato proteins. Some reactions occur during heat treatment, and the Maillard reaction is very important. Due to this reaction, the cooked product obtains an appetizing color, odor, and taste (Mottram et al., 2006). Based on this fact, the content of essential amino acids in potatoes cooked using different heat treatment methods has become particularly important (Harris, 1992). The amino acid analysis results imply that stir frying is a good cooking method to retain more essential amino acids in shredded potatoes

## Fat

Fat analysis showed that the fresh potatoes of the three varieties possessed a low fat content (Table 1), with the fat content being approximately 0.10 (g/100 g), which is in agreement with the fact that potato has a lower fat content

**Table 2** Amino acid compositions of stir-fried shredded potatoes before and after cooking on a fresh-weight basis. Different lowercase letters indicate significant differences ( $p < 0.05$ ) between the different samples.

Amino acids (g/100 g)	Dingshu 3		Dingshu 4		Market	
	Before	After	Before	After	Before	After
Alanine	0.05 ± 0.01 ab	0.04 ± 0.01 b	0.06 ± 0.01 a	0.04 ± 0.01 b	0.06 ± 0.01 a	0.04 ± 0.00 b
Serine	0.08 ± 0.01 a	0.06 ± 0.01 b	0.09 ± 0.00 a	0.06 ± 0.01 b	0.09 ± 0.01 a	0.06 ± 0.01 b
Leucine*	0.16 ± 0.02	0.14 ± 0.02	0.16 ± 0.02	0.12 ± 0.01	0.16 ± 0.03	0.13 ± 0.02
Aspartic acid	0.52 ± 0.02 a	0.26 ± 0.04 b	0.53 ± 0.02 a	0.30 ± 0.02 b	0.57 ± 0.04 a	0.29 ± 0.03 b
Isoleucine*	0.07 ± 0.00 ab	0.07 ± 0.02 ab	0.08 ± 0.00 a	0.06 ± 0.01 b	0.07 ± 0.00 ab	0.06 ± 0.01 b
Glycine	0.06 ± 0.01 ab	0.05 ± 0.01 ab	0.07 ± 0.02 a	0.04 ± 0.01 b	0.07 ± 0.01 a	0.05 ± 0.01 ab
Arginine*	0.12 ± 0.02 a	0.08 ± 0.01 b	0.10 ± 0.02 ab	0.08 ± 0.01 b	0.12 ± 0.01 a	0.08 ± 0.01 b
Histidine*	0.04 ± 0.01 ab	0.03 ± 0.01 b	0.05 ± 0.01 a	0.04 ± 0.01 ab	0.05 ± 0.01 a	0.04 ± 0.00 ab
Valine*	0.11 ± 0.01	0.10 ± 0.01	0.12 ± 0.02	0.10 ± 0.01	0.11 ± 0.01	0.10 ± 0.01
Proline	0.08 ± 0.01 cd	0.10 ± 0.02 bc	0.11 ± 0.01 b	0.07 ± 0.01 d	0.17 ± 0.02 a	0.08 ± 0.00 cd
Threonine*	0.09 ± 0.01 ab	0.06 ± 0.02 c	0.10 ± 0.01 a	0.06 ± 0.02 c	0.10 ± 0.00 a	0.07 ± 0.01 bc
Phenylalanine*	0.09 ± 0.00 b	0.08 ± 0.00 c	0.10 ± 0.00 a	0.08 ± 0.00 c	0.09 ± 0.01 b	0.08 ± 0.00 c
Methionine*	0.00 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.00 ± 0.00	0.01 ± 0.00	0.00 ± 0.00
Glutamic acid	0.28 ± 0.02 bc	0.21 ± 0.01 c	0.30 ± 0.03 ab	0.26 ± 0.10 bc	0.37 ± 0.02 a	0.21 ± 0.01 c
Lysine*	0.14 ± 0.03	0.12 ± 0.04	0.14 ± 0.01	0.11 ± 0.03	0.14 ± 0.02	0.11 ± 0.02
Tyrosine	0.13 ± 0.00	0.13 ± 0.02	0.12 ± 0.03	0.10 ± 0.02	0.12 ± 0.01	0.10 ± 0.02
TNAA	1.12 ± 0.04 b	0.75 ± 0.06 c	1.17 ± 0.07 b	0.80 ± 0.06 c	1.28 ± 0.05 a	0.75 ± 0.01 c
TEAA	0.82 ± 0.02 a	0.68 ± 0.11 b	0.86 ± 0.03 a	0.65 ± 0.04 b	0.85 ± 0.05 a	0.67 ± 0.05 b
TAA	1.94 ± 0.06 b	1.43 ± 0.16 c	2.03 ± 0.10 ab	1.45 ± 0.10 c	2.13 ± 0.10 a	1.42 ± 0.04 c
EAA	42.28 ± 0.45 bc	47.42 ± 2.35 a	42.39 ± 0.75 bc	44.85 ± 0.77 ab	39.89 ± 0.52 c	47.14 ± 2.19 a

\* Essential amino acids; TNAA = Total non-essential amino acids, TEAA = Total essential amino acids, TAA = Total amino acids, EAA = The ratio of essential amino acids to total amino acids

(Zhou et al., 2019). The fat content in potatoes is very low. After processing by different cooking methods, the fat content also changes to varying degrees. From Table 1, we can see that the fat content in stir-fried shredded potatoes among the three varieties increased significantly. Dingshu 4 potatoes showed the highest fat content ( $2.80 \pm 0.27$  g/100 g), while Dingshu 3 potatoes possessed the lowest content ( $1.60 \pm 0.10$  g/100 g), but the increase in fat content was much lower than that reported by Murniece et al. (2011). In the first research year, after the potatoes were harvested, the highest fat content was found in deep-fat fried potatoes of the Lenora variety ( $10.82 \pm 0.08$  g/100 g), and the lowest fat content was found in shallow-fried potatoes of the Lenora variety ( $3.43 \pm 0.08$  g/100 g). The method of stir frying used to cook the shredded potatoes in this study results in a much lower increase in fat content than deep-fat frying and shallow frying. Deep frying can cause rapid loss of water, oxidation and solidification of the surface and close the cell gap to form a denser surface layer. However, due to the higher water loss rate during frying, the potato also absorbs more fat, making the fried potato possess the highest fat content. This indicates that stir frying shredded potatoes may serve as an effective method to reduce the fat content compared with the deep fat frying and shallow frying.

## Dietary fiber

As shown in Table 1, the highest total dietary fiber ( $2.58 \pm 0.13$  g/100 g) and insoluble dietary fiber ( $1.72 \pm 0.08$  g/100 g) contents were found in uncooked Dingshu 3 potatoes, and Dingshu 4 potatoes possessed the highest content of soluble dietary fiber ( $1.37 \pm 0.16$  g/100 g). It is worth noting that the dietary fiber content was significantly elevated in stir-fried shredded potatoes of the three varieties. The total dietary fiber content of the Dingshu 3, Dingshu 4, and market potatoes increased by 1.54, 0.86, and 3.74 times, respectively. The insoluble dietary fiber content increased by 1.65, 1.22, and 2.03 times. The soluble dietary fiber content increased by 1.31, 0.55, and 5.87 times. The most pronounced increase in dietary fiber was observed in the market potato variety followed by Dingshu 3 potatoes, and the lowest increase in dietary fiber was observed in the Dingshu 4 variety. Numerous reports have suggested that cooking can increase the dietary fiber content of potatoes due to structural changes in polysaccharides and resistant starch in potatoes after cooking. Mullin et al. (1991) found that the apparent total dietary fiber content increased after all cooking methods. In new potatoes, the increase was mainly due to an increase in insoluble fiber content, but both soluble and insoluble dietary fiber contents increased in stored potatoes. Thed et al. (1995) reported that microwave heating

and deep frying significantly increased the insoluble dietary fiber content, while boiling and baking had a less marked effect. Soluble dietary fiber content was not affected by any of the cooking methods studied. Murniece et al. (2011) concluded that after shallow frying ( $150 \pm 5$  °C), deep-fat frying ( $180 \pm 5$  °C) and roasting ( $210 \pm 5$  °C), the dietary fiber contents in all five varieties of potatoes were increased significantly, which may have been due to the formation of resistant starch during frying (Yadav, 2011). The increase in dietary fiber after domestic cooking may be because of the formation of complexes between polysaccharides and other compounds in the food (such as protein) and the formation of resistant starch (RS) in cooked potatoes (Dhingra et al., 2012). Tian et al. (2016) found that cooking will increase the content of dietary fiber. According to the USDA National Nutrient Database for Standard Reference (2008), the dietary fiber content of a boiled potato is 1.87 g/100 g (with skin; fresh weight), while that of a baked potato is 2.5 g/100 g, and that of French fries, frozen and then oven-heated potatoes is 2.66 g/100 g. In comparison with the methods analyzed in these studies, the method of stir frying shredded potatoes seems to better retain dietary fiber.

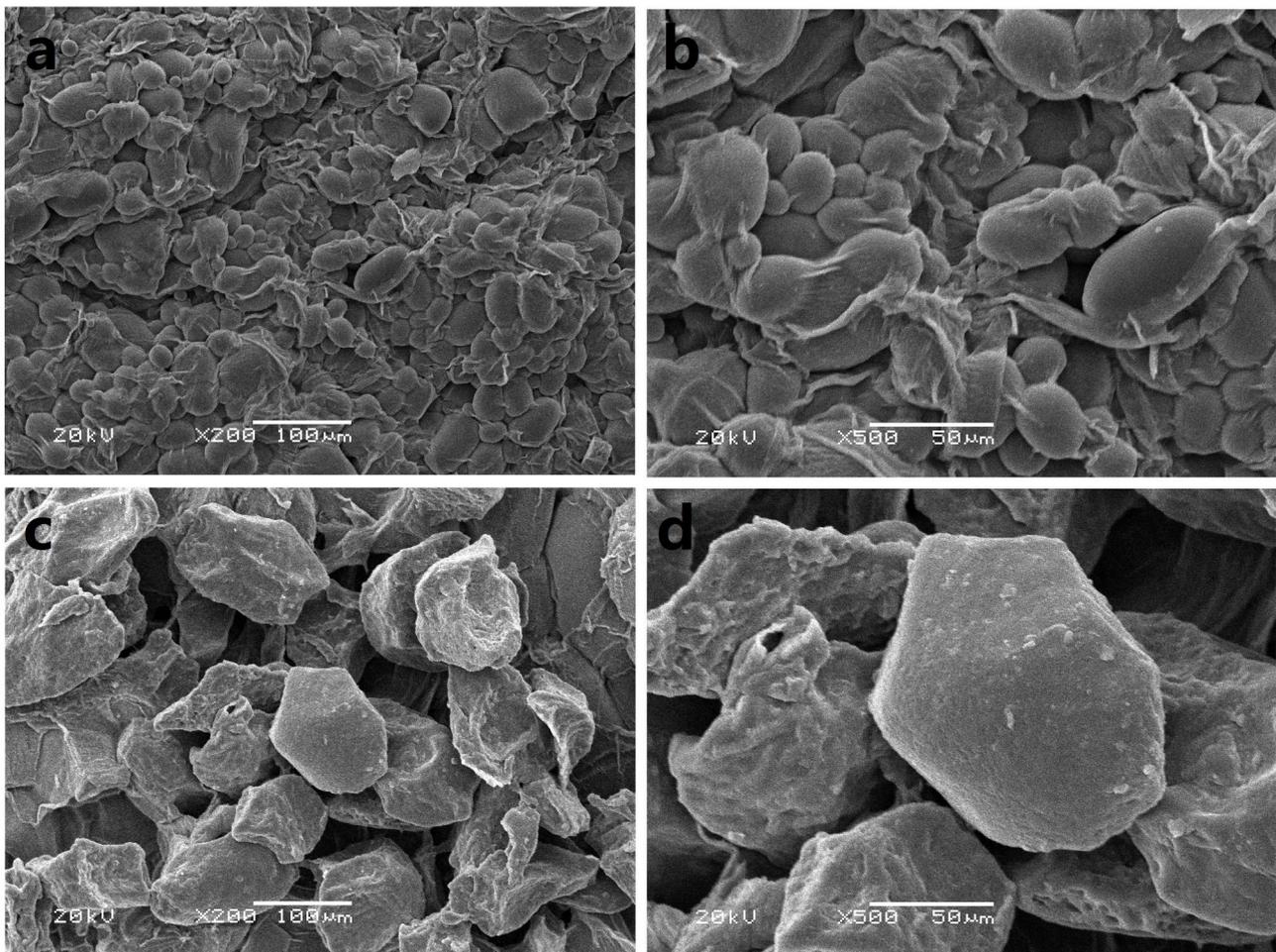
## Minerals

As shown in Table 1, significant differences in the levels of minerals except Ca were detected among the varieties of fresh potatoes. The Dingshu 4 variety showed the highest content of P, and the Dingshu 3 variety exhibited the highest contents of Mg and K. The results of mineral content analysis also showed that the P, Mg, and K contents of stir-fried shredded potatoes of all three varieties were significantly decreased, while the Ca content was significantly increased compared with that of fresh potatoes. The P levels in the Dingshu 3, Dingshu 4, and market varieties decreased by 26.47%, 37.20%, and 29.64%, respectively. The Mg level decreased by 38.13%, 31.80%, and 11.95%. The K level decreased by 67.18%, 62.06%, and 61.14%. The Ca contents of the Dingshu 3, Dingshu 4, and market varieties increased by 4.65, 5.77, and 4.68 times, respectively. Bethke et al. reported that boiling tuber cubes and shredded tubers decreased K levels by 50% and 75%, respectively (Bethke and Jansky, 2008). Nutrition data from the United States Department of Agriculture (USDA) show that steaming and boiling are more likely to cause mineral loss than other cooking methods. In this study, the potatoes were cooked in two steps, i.e., shallow boiling and stir frying, and higher potassium loss may have been caused by this cooking method. The higher calcium content may have been due to the light boiling step because water has higher calcium content. The mineral content in the cooking water was tested. The result

showed that the content of Ca in the cooking water was 21.38mg/kg, the Mg was 2.48 mg/kg, the P was 0.12 mg/L. The content of K in the cooking water was not detected and the result was below the detection limit (0.5mg/100 g). This result showed that the content of K in the cooking water was very low. The same as we inferred that the cooking water had contained high amount of Ca. This may have also been because the formation of complexes or separation of compounds resulting from the Maillard reaction may affect the solubility and availability of some minerals (Adebiyi et al., 2017). The specific mechanism needs to be further studied. These results demonstrate that those who must reduce their potassium uptake but increase their calcium intake could use the method of stir frying to cook shredded potatoes.

## Vitamins

As shown in Table 1, differences in the contents of vitamins were found among the three varieties. The market variety showed the highest vitamin C content ( $25.00 \pm 1.11 \mu\text{g}/100 \text{g}$ ) but possessed the lowest vitamin B<sub>6</sub> ( $0.281 \pm 0.009 \mu\text{g}/100 \text{g}$ ) and vitamin B<sub>1</sub> ( $0.065 \pm 0.010 \mu\text{g}/100 \text{g}$ ) contents. The vitamin content of the three varieties was reduced to varying degrees after cooking. The vitamin C levels of the Dingshu 3, Dingshu 4, and market varieties decreased by 30%, 12.5%, and 20%, respectively. The vitamin B<sub>6</sub> content was reduced by 37.56%, 35.68%, and 17.79%. Vitamin B<sub>1</sub> content was reduced by 59.41%, 63.64% and 52.31%. Potatoes are a readily available source of vitamins (Kondo et al., 2011). Due to the heat sensitivity of vitamins, it is very easy to lose vitamins during cooking (Dale et al., 2003; Xu et al., 2018). Vitamin C loss depends on the location, cultivar, time of harvest, maturity, conditions and storage period, and cooking methods (Emília et al., 2006).



**Fig. 2** Scanning electron micrographs of starches of stir-fried shredded potatoes before and after cooking: (a) before (×200); (b) before (×500); (c) after (×200); (d) after (×500)

Mooney et al., (2013) reported that the content of vitamin B<sub>6</sub> varied significantly among different genotypes and under long-term storage conditions in potatoes. Goyer et al. (2019) detected changes in the amounts of vitamin B<sub>6</sub> and vitamin C in five potato varieties stored at 7.8°C for 8 months in 2015 and 2016, and found that storage at low temperature substantially affects tuber nutritional quality.

## Starch and resistant starch

As shown in Table 1, the market variety showed the highest content of starch ( $19.20 \pm 0.44$  g/100 g), followed by the Dingshu 3 variety ( $15.60 \pm 0.62$  g/100 g), and the lowest starch content was detected in the Dingshu 4 variety ( $12.70 \pm 0.75$  g/100 g). The starch content of potatoes was reduced after cooking, but only the Dingshu 3 variety showed significant differences. Potatoes are regarded as a good source of energy owing to their high starch content. Starch is the second most abundant component in potatoes (Smith, 1975). The loss of potato starch may have been due to the leaching of starch during the washing process before cooking. It is also possible that starch granules were destroyed and degraded during the cooking process. Temperature and time are two important factors affecting potato starch content. High temperature has a direct destructive effect on starch (Fillion and Henry, 1998). However, the starch content was showed to be increased in a report by Murniece et al. (2011). In the second research year, the starch content increased in all five potato varieties subjected to three traditional cooking methods. The highest starch content increase was found in deep fat-fried potatoes. The starch content in stir-fried shredded potatoes was lower after cooking. This may have been because during the whole cooking process, most potatoes are exposed to air. Only when they come into contact with the bottom of the pot or oil is the temperature higher. The amount of heat used in this cooking method is far lower than that used in the deep-fat frying process.

Figure 2 shows SEM images of starch granules in stir-fried shredded potatoes. Figure 2(a)-(b) shows samples of potato starch before cooking at different magnifications (200× and 500×); pictures c-d show samples of starch granules after cooking at different magnifications (200× and 500×). As shown in Fig. 2, potato starch particles vary in size, the shape of starch granules of samples a-b is ellipsoidal, similar to native potato starch, and the cell wall is visible (Zeng et al., 2014). The surface of the starch particles is very smooth, without protruding and straight edges. This is consistent with the morphology of potato starch reported in the literature (Mishra and Rai, 2006). After cooking, significant changes occurred on the surface of potato starch granules, but they still possessed well-defined edges (Fig. 2c-d).

Starch granules gradually began to lose their ellipsoidal appearance, but the potato starch was not completely gelatinized. This may have been due to the increase in the treatment temperature, making the starch granules more cracked. Koch et al. studied the morphology changes of different starch particles after gelatinization. The surface of potato starch is flat, indicating that gelatinization acts uniformly on the surface of the starch, and there is no special structure on the surface of the original starch particles (Koch and Jane, 2000). The content of resistant starch decreases significantly when the starch is gelatinized (Bach et al., 2013). Incomplete gelatinization of starch granules in stir-fried shredded potatoes may result in less loss of resistant starch.

As shown in Table 1, the resistant starch content in the three varieties was reduced after the potatoes were stir-fried. The main reason for the loss of resistant starch is that the starch structure is destroyed under high temperature, and hydrogen bonds between starch molecules are broken so that  $\alpha$ -amylase easily enters the interior of the starch granules, resulting in a reduction in digestion resistance. The unique crystalline structure of raw potato starch is resistant to human digestive enzymes, while starch is gelatinized, resulting in increased solubility and digestibility under different cooking conditions. The starch structure is changed in cooled potatoes after cooking through a process called retrogradation, making potato starch resistant to digestive enzymes again (Leeman et al., 2005). However, the degradation mechanism of potato resistant starch in this cooking process needs to be further studied. In our study, stir-fried shredded potatoes were cooked in two steps: shallow boiling and stir frying. During shallow boiling, the moisture content is relatively sufficient, which can cause starch granules to swell and reduce their inability to be digested. However, the processing time in this study was relatively short. Therefore, we conclude that this cooking method resulted in less loss of potato starch and resistant starch content. It has been reported that commercially processed potato products have a higher resistant starch content of 4.8–9.0% of total starch, but resistant starch content is only 2.0% in boiled potatoes (Liljeberg, 2002). Resistant starch accounts for up to 20% of the total starch in stir-fried shredded potatoes of the Dingshu 3 and Dingshu 4 varieties. This shows that stir frying is a very good cooking method to reduce the loss of resistant starch in shredded potatoes.

## Amino acids

### Glycoalkaloids

Table 3 shows that the glycoalkaloid contents in these three potato cultivars varied significantly. Notably, the market variety possessed the highest content of glycoalkaloids (11.39 mg/kg), whereas Dingshu 4 potatoes contained the lowest level of glycoalkaloids (4.20 mg/kg). The results showed that glycoalkaloid levels in the three potato cultivars were much lower than the international safety limit of 200 mg/kg FW. According to Friedman et al. (2003), the content of glycoalkaloids can vary significantly in different potato cultivars and is enhanced postharvest by environmental factors, such as storage, light, and mechanical injury. The high level of glycoalkaloids in the market potatoes may have been due to improper storage conditions.

From Table 3, we can see that the contents of glycoalkaloids were significantly decreased in stir-fried shredded potatoes of the three varieties in comparison to uncooked potatoes. The glycoalkaloid levels in the Dingshu 3, Dingshu 4, and market varieties decreased by 73.33%, 57.14%, and 83.58%, respectively. Peeling plays a very important role in the removal of glycoalkaloids from potatoes. There has also been much research on glycoalkaloids in potatoes during cooking. Nie et al. (2018) reported that frying can significantly decrease the content of glycoalkaloids in potato chips, which can be attributed to temperature. In this article, stir-fried shredded potatoes were cooked in two steps, shallow boiling and stir frying, and the higher glycoalkaloid loss may have been caused by this cooking method. Therefore, we can be sure that these processing methods that are used in Chinese households can effectively reduce the glycoalkaloid concentration.

**Glycoalkaloid content of various varieties prepared by stir-fried shredded potatoes before and after cooking on a fresh-weight basis. Different lowercase letters indicate significant differences ( $p < 0.05$ ) between the different samples**

Varieties	Treatment	$\alpha$ -chaconine (mg/kg) (A)	$\alpha$ -solanine (mg/kg) (B)	Total (A+B)
Dingshu 3	Before	3.02 ± 0.11 b	3.58 ± 0.14 b	6.60
	After	1.14 ± 0.09 d	0.62 ± 0.21 d	1.76
Dingshu 4	Before	2.24 ± 0.01 c	1.96 ± 0.22 c	4.20
	After	1.13 ± 0.02 d	0.67 ± 0.01 d	1.80
Market	Before	3.71 ± 0.39 a	7.68 ± 0.64 a	11.39
	After	1.17 ± 0.02 d	0.70 ± 0.00 d	1.87

## Volatile aroma compound analysis

Volatile profile analysis by TD-GC/MS showed a large number of compounds in both uncooked potatoes and stir-fried shredded potatoes. Table 4 displays details on the volatile aroma compounds. A total of 74 volatile aroma compounds were identified, including hydrocarbons, aromatic hydrocarbons, alcohols, aldehydes, ketones, esters, furans, ethers, and other compounds.

- Methyloctane (no. 42), hexanal (no. 47),  $\alpha$ -phellandrene (no. 49),  $\gamma$ -terpinene (no. 51), *o*-cymene (no. 53), diallyl disulfide (no. 57), and linalool (no. 58) were found only in the stir-fried shredded potato samples.

Josephson et al. (1987) analyzed the volatile aroma compounds of boiled potatoes and found that the content of hexanal was higher. A study by Petersen et al. (1999) showed that hexanal has a potential effect on the unpleasant flavor of cooked potatoes.

$\alpha$ -Phellandrene (no. 49) is approved as a food flavor according to the Chinese National Standard Method GB 2760–1996 and can also be used in medicine, cosmetics, toothpaste, and shaving supplies.  $\alpha$ -Phellandrene is widely found in eucalyptus oil, cumin oil, cinnamon leaf oil, orange peel oil, pepper, laurel oil, linseed oil, turpentine, and other volatile oils.  $\alpha$ -Phellandrene has a cooling sensation on the skin and a pleasant aroma. It has a mild irritating effect on the bronchi and can be made inhaled as an expectorant.  $\alpha$ -Phellandrene is not very stable. It is easily decomposed by distillation under normal pressure and forms  $\alpha$ -terpinene and  $\gamma$ -terpinene in sulfuric acid-ethanol solution. As shown in Table 4,  $\alpha$ -terpinene was detected in stir-fried shredded potatoes of the Dingshu 3 and Dingshu 4 varieties.

$\alpha$ -Terpinene is often presented as a mixture with  $\gamma$ -terpinene.  $\alpha$ -Terpinene has a citrus fragrance and is mainly used in the manufacturing of essential oils and fragrances. *Adenosma buchneroides Bonati* is a new perfume plant only found in China that is worthy of further development. The main volatile aroma component is  $\gamma$ -terpinene.

As a natural spice tree species, camphor trees are planted in a large area. It is not only an excellent green tree species in China but also a precious spice tree species. Camphor trees have an aromatic smell, and essential oils can be extracted from their roots, branches, and fruits. It has been determined that the main component of camphor oil is *o*-cymene. The volatile aroma compound analysis showed that *o*-cymene (no. 53) was found only in the stir-fried shredded potato samples. *o*-Cymene was not identified in uncooked potato samples. This result indicated that unlike uncooked potato samples, the stir-fried shredded potatoes had an aroma like *o*-Cymene. Diallyl disulfide is the main component of garlic

**Table 4** Volatile components in potatoes and stir-fried shredded potatoes identified by TD-GC/MS

Peak No.	Compounds	Formula	Relative content (%)					
			Potatoes			Stir-fried shredded potatoes		
			Dingshu 3	Dingshu 4	Market	Dingshu 3	Dingshu 4	Market
1	n-Hexane	C <sub>6</sub> H <sub>14</sub>	28.44	17.51	33.34	34.33	10.90	15.84
2	Methylcyclopentane	C <sub>6</sub> H <sub>12</sub>	1.38	nd	1.29	0.55	nd	nd
3	Cyclohexane	C <sub>6</sub> H <sub>12</sub>	0.76	nd	1.04	0.35	nd	nd
4	Hexamethylcyclotrisiloxane	C <sub>6</sub> H <sub>18</sub> O <sub>3</sub> Si <sub>3</sub>	1.22	nd	0.37	0.14	0.07	0.13
5	Octamethylcyclotetrasiloxane	C <sub>8</sub> H <sub>24</sub> O <sub>4</sub> Si <sub>4</sub>	2.13	nd	1.48	2.56	nd	nd
6	Benzene	C <sub>6</sub> H <sub>6</sub>	0.90	0.83	1.07	0.29	0.12	0.33
7	Tetrachloroethylene	C <sub>2</sub> Cl <sub>4</sub>	5.25	5.19	5.15	3.68	2.02	3.65
8	Toluene	C <sub>7</sub> H <sub>8</sub>	3.01	2.32	2.62	1.06	0.69	0.95
9	Decamethylcyclopentasiloxane	C <sub>10</sub> H <sub>30</sub> O <sub>5</sub> Si <sub>5</sub>	2.00	1.08	1.11	0.54	0.55	0.61
10	Ethylbenzene	C <sub>8</sub> H <sub>10</sub>	0.88	nd	0.89	nd	nd	nd
11	m-Xylene	C <sub>8</sub> H <sub>10</sub>	1.29	nd	0.51	0.43	nd	nd
12	β-Myrcene	C <sub>10</sub> H <sub>16</sub>	nd	nd	nd	0.83	0.84	nd
13	p-Xylene	C <sub>8</sub> H <sub>10</sub>	0.59	nd	0.60	0.58	nd	nd
14	β-Phellandrene	C <sub>10</sub> H <sub>16</sub>	0.49	nd	nd	2.62	nd	3.04
15	1,8-Cineole	C <sub>10</sub> H <sub>18</sub> O	0.36	0.16	0.18	1.12	3.27	0.98
16	Dodecamethylcyclohexasiloxane	C <sub>12</sub> H <sub>36</sub> O <sub>6</sub> Si <sub>6</sub>	1.14	0.29	0.90	0.44	0.17	0.20
17	Octanal	C <sub>8</sub> H <sub>16</sub> O	1.40	nd	0.65	0.36	nd	0.43
18	6-Methyl-5-hepten-2-one	C <sub>8</sub> H <sub>14</sub> O	0.56	1.92	2.79	1.12	0.82	0.47
19	1-Nonanal	C <sub>9</sub> H <sub>18</sub> O	8.98	1.11	1.75	1.96	1.62	1.43
20	2-Butoxyethanol	C <sub>6</sub> H <sub>14</sub> O <sub>2</sub>	1.69	2.81	1.62	1.15	1.09	0.95
21	2-Methylbutane	C <sub>5</sub> H <sub>12</sub>	nd	0.85	nd	nd	0.31	0.44
22	6-Methylheptanol	C <sub>8</sub> H <sub>18</sub> O	nd	0.16	nd	nd	nd	nd
23	3,4-dimethyl-1-hexene	C <sub>8</sub> H <sub>16</sub>	nd	0.08	nd	nd	0.03	nd
24	Dichloromethane	CH <sub>2</sub> Cl <sub>2</sub>	nd	4.08	nd	nd	nd	nd
25	Trichloromethane	CHCl <sub>3</sub>	nd	0.56	0.42	nd	nd	nd
26	2-Ethylhexanol	C <sub>8</sub> H <sub>18</sub> O	nd	2.31	4.18	2.72	nd	nd
27	Butylated Hydroxytoluene	C <sub>15</sub> H <sub>24</sub> O	nd	6.62	nd	4.29	9.15	nd
28	n-Octane	C <sub>8</sub> H <sub>18</sub>	nd	nd	0.08	nd	nd	nd
29	Ethyl acetate	C <sub>4</sub> H <sub>8</sub> O <sub>2</sub>	nd	nd	0.36	nd	nd	nd
30	3-Methylcyclopentanol	C <sub>6</sub> H <sub>12</sub> O	nd	nd	0.39	nd	nd	nd
31	Sabinene	C <sub>10</sub> H <sub>16</sub>	nd	nd	nd	3.62	4.91	nd
32	n-Hexadecane	C <sub>16</sub> H <sub>34</sub>	nd	nd	0.10	nd	nd	nd
33	Heptaldehyde	C <sub>7</sub> H <sub>14</sub> O	nd	nd	0.11	0.12	nd	nd
34	2-Pentylfuran	C <sub>9</sub> H <sub>14</sub> O	nd	nd	0.15	nd	nd	nd
35	3-Ethyltoluene	C <sub>9</sub> H <sub>12</sub>	nd	nd	0.05	nd	nd	nd
36	1,3,5,7-Cyclooctatetraene	C <sub>8</sub> H <sub>8</sub>	nd	nd	0.24	nd	nd	nd
37	n-Tridecane	C <sub>13</sub> H <sub>28</sub>	nd	nd	0.16	nd	nd	nd
38	Tetradecane	C <sub>14</sub> H <sub>30</sub>	nd	nd	0.54	0.38	nd	nd
39	Decanal	C <sub>10</sub> H <sub>20</sub> O	nd	nd	1.56	0.71	nd	nd
40	Hexadecamethylcyclooctasiloxane	C <sub>16</sub> H <sub>48</sub> O <sub>8</sub> Si <sub>8</sub>	nd	nd	0.24	0.31	nd	nd
41	2,4-Dimethyl-heptane	C <sub>9</sub> H <sub>20</sub>	nd	nd	nd	0.56	nd	0.46
42	4-Methyloctane	C <sub>9</sub> H <sub>20</sub>	nd	nd	nd	0.52	0.02	0.43
43	2,4-Dimethyl-1-heptene	C <sub>9</sub> H <sub>18</sub>	nd	nd	nd	0.23	0.09	nd
44	n-Nonane	C <sub>9</sub> H <sub>20</sub>	nd	nd	nd	0.43	nd	0.26
45	2-Methylbutyraldehyde	C <sub>5</sub> H <sub>10</sub> O	nd	nd	nd	0.36	nd	nd
46	2,6,10-trimethyl-Dodecane	C <sub>15</sub> H <sub>32</sub>	nd	nd	nd	0.10	nd	0.26
47	Hexanal	C <sub>6</sub> H <sub>12</sub> O	nd	nd	nd	0.62	0.32	0.70
48	Diallyl sulfide	C <sub>6</sub> H <sub>10</sub> S	nd	nd	nd	0.64	nd	nd
49	α-Phellandrene	C <sub>10</sub> H <sub>16</sub>	nd	nd	nd	0.38	0.43	0.23
50	α-Terpinene	C <sub>10</sub> H <sub>16</sub>	nd	nd	nd	0.76	0.67	nd
51	γ-Terpinene	C <sub>10</sub> H <sub>16</sub>	nd	nd	nd	1.48	0.99	0.48
52	Styrene	C <sub>8</sub> H <sub>8</sub>	nd	nd	nd	0.14	nd	nd
53	o-Cymene	C <sub>10</sub> H <sub>14</sub>	nd	nd	nd	0.19	1.73	1.23

**Table 4** (continued)

Peak No.	Compounds	Formula	Relative content (%)					
			Potatoes			Stir-fried shredded potatoes		
			Dingshu 3	Dingshu 4	Market	Dingshu 3	Dingshu 4	Market
54	4-Methylpyrimidine	C <sub>5</sub> H <sub>6</sub> N <sub>2</sub>	nd	nd	nd	0.08	nd	nd
55	Terpinolene	C <sub>10</sub> H <sub>16</sub>	nd	nd	nd	0.62	nd	nd
56	Tetradecamethylcycloheptasiloxane	C <sub>14</sub> H <sub>42</sub> O <sub>7</sub> Si <sub>7</sub>	nd	nd	nd	0.80	nd	nd
57	Diallyl disulfide	C <sub>6</sub> H <sub>10</sub> S <sub>2</sub>	nd	nd	nd	3.11	4.00	7.36
58	Linalool	C <sub>10</sub> H <sub>18</sub> O	nd	nd	nd	0.78	0.98	0.37
59	Terpinen-4-ol	C <sub>10</sub> H <sub>18</sub> O	nd	nd	nd	0.64	0.71	nd
60	2,4-Dimethylhexane	C <sub>8</sub> H <sub>18</sub>	nd	nd	nd	nd	0.23	nd
61	Acetone	C <sub>3</sub> H <sub>6</sub> O	nd	nd	nd	nd	1.20	1.06
62	Dichloromethane	CH <sub>2</sub> Cl <sub>2</sub>	nd	nd	nd	nd	1.95	2.04
63	Decane	C <sub>10</sub> H <sub>22</sub>	nd	nd	nd	nd	0.11	nd
64	β-Pinene	C <sub>10</sub> H <sub>16</sub>	nd	nd	nd	nd	0.33	nd
65	1-Undecyne	C <sub>11</sub> H <sub>20</sub>	nd	nd	nd	nd	0.17	nd
66	Styrene	C <sub>8</sub> H <sub>8</sub>	nd	nd	nd	nd	0.08	0.03
67	3-Methylcrotonitrile	C <sub>5</sub> H <sub>7</sub> N	nd	nd	nd	nd	1.08	nd
68	1,2-Epoxyoctahydro-1H-benzofuran	C <sub>7</sub> H <sub>12</sub> O	nd	nd	nd	nd	0.08	nd
69	5-Hexenenitrile	C <sub>6</sub> H <sub>9</sub> N	nd	nd	nd	nd	0.31	nd
70	Furfural	C <sub>5</sub> H <sub>4</sub> O <sub>2</sub>	nd	nd	nd	nd	0.19	nd
71	Cyclohexyl isothiocyanate	C <sub>7</sub> H <sub>11</sub> NS	nd	nd	nd	nd	2.12	nd
72	1,1,4-Trimethylcyclohexane	C <sub>9</sub> H <sub>18</sub>	nd	nd	nd	nd	nd	0.24
73	D-Limonene	C <sub>10</sub> H <sub>16</sub>	nd	nd	nd	nd	nd	1.92
74	Methyl allyl disulfide	C <sub>4</sub> H <sub>8</sub> S <sub>2</sub>	nd	nd	nd	nd	nd	0.95

oil and is common in allium plants, such as onions and garlic. Garlic and other allium plants release allicin after being cut, and then the allicin is decomposed into diallyl disulfide, which can be used as food seasoning (Hughes et al., 2005).

Linalool is a commonly occurring monoterpene, and natural linalool has a beautiful and pleasant aroma. Linalool is the main aroma component in pu-erh teas with a floral-fruity flavor and *Rhododendron fortunei*. Linalool has anti-inflammatory effects. Peana et al. (2002) found that natural linalool can alleviate edema, and the results obtained indicate that linalool has anti-inflammatory activity. Li et al. (2015) reported that linalool can inhibit LPS-induced inflammation in BV2 microglial cells by activating the Nrf2/HO-1 signaling pathway.

Benzene (no. 6), 1,8-cineole (no. 15), 6-methyl-5-hepten-2-one (no. 18) and 1-nonanal (no. 19) were detected in all samples.

Benzene (no. 6) was detected in all samples, and the content in stir-fried shredded potatoes was lower than that in uncooked potatoes.

1,8-Cineole (no. 15) is often used to formulate lavender essential oils. It can also be used in the production of flavors, medicinal soaps, sprays, etc. It has high antibacterial and antitumor activities. In medicine, it is often used as an antipyretic, anti-inflammatory, antiseptic, antiasthmatic and analgesic (Moteki et al., 2002).

- Methyl-5-hepten-2-one (no. 18) has a fruity aroma and a fresh fragrance aroma and is widely found in various essential oils. It is stipulated by Chinese National Standard GB 2760-86 as a permitted flavor and is mainly used in the preparation of banana, pear, citrus, and berry flavors.
- Nonanal (no. 19) has aromas of roses and citrus, has a strong smell of oil and fat, is found in red tea and green tea and is widely used in flavor formulations. It can also be used in food flavors, such as citrus formulas. Chinese National Standard GB2760-1996 stipulates that it is a permitted food flavor.

Solms et al. (1994) believes that the content and sensory quality of potato flavor compounds are related to the variety, cultivation conditions, storage conditions, and processing methods and show genotype specificity. In this study, although some volatile aroma compounds were not detected in all samples, they still contributed to the flavor of the stir-fried shredded potatoes. β-Myrcene (no. 12) and sabinene (no. 31) were detected in the stir-fried shredded potatoes of the Dingshu 3 and Dingshu 4 varieties. β-Myrcene and sabinene are important volatile aroma compounds found in Sichuan pepper and chili pepper.

Related studies have shown that terpenes are the most volatile components in citrus essential oils, and β-myrcene (no. 12) and sabinene (no. 31) are considered the most important odor-contributing components. β-Myrcene has a

pleasant and light balm odor (Liu et al., 2012). Octanal (no. 17) was detected in both uncooked potatoes and stir-fried shredded potatoes of the Dingshu 3 and market varieties. Octanal has aroma similar to rose and orange peel. It is used in the food industry to produce sweet orange aromas.

## Conclusions

Potatoes are rich in nutrients. However, people eat potatoes processed by different cooking methods in daily life. During cooking processes, complex conditions can easily change the structure and properties of many nutrients. At present, relevant data on the content of various nutrients in stir-fried shredded potatoes are still lacking, and estimation of residents' dietary nutrient intake based on the nutrient content of uncooked raw materials usually results in overestimation. Therefore, this study has strong guiding significance for optimizing the cooking method of stir-fried shredded potatoes and provides insight for a more scientific evaluation of the dietary nutritional status of residents. The stir-fried shredded potatoes in this study showed higher dietary fiber and calcium contents than potatoes prepared by other cooking methods and an excellent essential amino acid composition. Compared with deep fat-fried and shallow-fried potatoes, stir-fried shredded potatoes had a lower fat content. Stir frying led to a reduction in protein, starch, mineral (P, Mg, K), and vitamin contents. Incomplete gelatinization of starch granules in stir-fried shredded potatoes may have resulted in less loss of resistant starch. Moreover, this processing method, which is used in Chinese households, effectively reduced the glycoalkaloid concentration. Further volatile aroma compound analysis identified a total of 74 volatile aroma compounds, including hydrocarbons, aromatic hydrocarbons, alcohols, aldehydes, ketones, esters, furans, ethers, and other compounds. 4-Methyloctane (no. 42), hexanal (no. 47),  $\alpha$ -phellandrene (no. 49),  $\gamma$ -terpinene (no. 51), o-cymene (no. 53), diallyl disulfide (no. 57), and linalool (no. 58) were the main flavor-contributing components and were found only in the stir-fried shredded potato samples.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s12230-022-09872-5>.

**Acknowledgements** This work was supported by the National Key Research and Development Plan (2016YFD0401302-02, 2018YFF0213505), Chinese Agriculture Research System (CARS-10), the Modern Agricultural Industry Technology System of Gansu Province (GARS-03-P6), the National Agriculture Industry Standard Setting and Revision Program of China (2018-46).

## Declarations

**Conflict of interest** The authors have declared no conflicts of interest for this article. We state that the authors have no conflict of interest before references in the main manuscript with a heading of conflict of interest.

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