International Food Research Journal 26(5): 1495-1503 (October 2019)

Journal homepage: *http://www.ifrj.upm.edu.my*

A comprehensive quality system of six different varieties of mashed potatoes

Wang, H., Liu, H., Liu, J., Chen, Z., Li, J., Dong, N., Chen, Z., lv, D., Wang, M. and *Liu, Y.

Institute of Biotechnology in Guizhou Academy of Agricultural Sciences, Guizhou 550025, China

Article history

Received: 9 October, 2018
Received in revised form: 25 May, 2019
Accepted: 8 July, 2019

Keywords

Potato
Mashed potatoes
Flavour compounds
Principal component analysis

Abstract

In the present work, we used headspace solid phase micro-extraction combined with gas chromatography-mass spectrometry to test the flavour components of different varieties of mashed potatoes under different cooking times. The principal component analysis was then used to analyse the main aroma components of those six varieties of mashed potatoes under the op-timal cooking time. Finally, aroma evaluation model of mashed potatoes was established, and the texture and sensory evaluation of mashed potatoes were also implemented to evaluate a comprehensive quality system of chosen mashed potatoes. The present work may provide reference for companies to use the established instrumental sensory technique (HS-SPME and texture analysis) for quality control and to predict or prove the sensory property of the end product.

Introduction

Potato (*Solanum tuberosum* L.) is a starchy, tuberous crop from the Solanaceae family, which is the third most important food crops in the world after rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) in terms of human consumption (Muhammad *et al*., 2013; Majeed *et al*., 2014). Potato can be used as both food grain and vegetable. This nutrient-rich tuber con-tains high-quality starches, proteins, minerals, dietary fibre and vitamins (Yusuph *et al*., 2003; Burlingame *et al*., 2009). Potato contains more abundant crude fibre than rice and wheat flour, and its quality of protein, which is rich in lysine and tryptophan, is superior to that of soybean (*Glycine max* (L.) Merr.). Potato is rich in vitamin C and is thus known as “underground apple”. Its calorific value is one to three times higher than that of other identically measured vegetables, and is thus known as “second bread” and “the king of vegetables” (Reyniers *et al*., 2018; Glusac *et al*., 2018; Bagri, 2018a; 2018b). Potato is regarded as one of the best foods in the world and one of the ten most popular health foods in the new century. For more than 50 years, the potato industry has developed rapidly worldwide (FAOSTAT, 2015). In Western Europe, United States and Japan, potato has already become a staple food. In Africa, potato performs an increasingly important role in peo-ple’s daily life. In China, potato staple strategies have been proposed. De-veloping potato industry can solve the world food crisis, improve the dietary structure of people worldwide and promote sustainable agricultural devel-opment in various countries (Gancarz, 2018).

The development of the potato industry is mainly focused on research on potato planting and related products. Potato, which presents broad market prospect, can be used for fresh food and as raw material to produce various products, such as starch, French fries, potato chips, whole powder and pigments (Rafiq and Ghosh, 2017). The demand for potato and its subsidiary products become exceedingly high with the continuous promotion of the strategic position of potato worldwide. Hence, research and development on potato and its subsidiary products have become a hot research topic for scientists. Potato can be made into mashed potatoes after washing, peeling, removal of bud eye and cooking. This type of mashed potatoes exhibits superior palate, better flavour and better nutritional value to that prepared from potato flour (Álvarez *et al*., 2005; Miao *et al*., 2018). Mashed potatoes are one of the most popular potato products because of its ease of prepara-tion and consumption (Álvarez *et al*., 2011). In addition, cooked mashed

*Corresponding author.
Email: kittyliu0211@163.com

potatoes produce a variety of flavour components that can potentially result in unique flavour components. Various produced flavour components are re-lated to cooking time (Lu *et al*., 2016). However, few studies have reported the texture characteristics and main flavour components produced in dif-ferent breeds of mashed potatoes at different cooking times. In today's fast consumption era, the development of fast-food mashed potato is important for potato research and development.

In the present work, the texture characteristics of mashed potatoes were determined by texture analyser, and the main flavour components of mashed potatoes prepared from six different varieties of potatoes under different cooking times were determined by headspace solid-phase mi-cro-extraction and gas chromatography–mass spectrometry. Volatile flavour components in mashed potatoes were analysed by principal component analysis, and the evaluation model of the quality of mashed potatoes was established. We combined the aroma evaluation model, texture and sensory evaluation of mashed potatoes to evaluate a comprehensive quality system chosen mashed potatoes. The present work may provide a reference for companies to use the established instrumental sensory technique (HS-SPME and texture analysis) for quality control and to predict or prove the sensory property of the end product.

Materials and methods

Materials and reagents

Six different varieties of potatoes were used in the present work namely Zao Dabai (Zdb), Andover, Norland, Long Shu 3 (Ls 3), Hei Meiren (Hmr), and Hong Baoshi (Hbs), and were provided by the Institute of Bio-technology, Guizhou Academy of Agricultural Sciences in China. The harvest period was in May, 2018 and they had been stored in cellar (temperature: 5°C; relative humidity: 85%) for two months before they were made into mashed potatoes. All reagents were of analytical-grade.

Preparation of mashed potato

Good-quality potatoes with no rot, no mechanical injury, less bud, and smooth and uniform shape (about 7 cm in length and 5 cm in width) were used as raw materials for preparing mashed potatoes. The germinated, greened, and decayed potatoes were removed and then randomly sampled. Soil was thoroughly rinsed off with water. Next, the potatoes were peeled, sliced into 5-mm thick pieces by porcelain knives, and soaked in clear water to prevent browning. For making the aroma components and the taste of mashed potatoes to reach their optimal state, the fresh-cut potato was heated by steam until fully gelatinised under normal pressure. Cooking power was set as 1,600 W. Cooking time considerably influences the sensory and texture qualities of mashed potatoes. To determine the appropriate cooking time for potatoes, 0, 15 and 45 min were applied. Texture determination was imme-diately conducted after cooking to prevent the change in texture parameters caused by cooling. The manner and time of mashing considerably influence the quality and taste of mashed potatoes. Excessive mashing of potatoes could damage cells and destroy the starch structure and thus was avoided. The cooked mashed potatoes would be hard if they were mashed too slightly during consumption (Álvarez *et al*., 2011). The texture of mashed potatoes was considered as an index during the ex-periment. The extruder used in the experiment was a DOOPO juice press (model D9501, Shanghai, China).

Texture determination of mashed potato

A TA-XT2i texture analyser (Texture Analyser, Stable Micro System, United Kingdom) was used to measure the texture characteristics of mashed potatoes at room temperature. The sample was placed on the sample stage. The setting mode was as follows: experimental speed: 2.0 mm/s, return speed: 10.0 mm/s, test distance: 15 mm/45 mm (tuber/mashed potato), in-ductive force: Auto - 5 g, data take points: 200 pps. The texture analyser was continuously compressed twice; each time compressed to 90% of the original height of the product, and the experimental data was read by the computer.

Analysis of main flavour compounds of mashed potato for different cooking times

Exactly 1.5 g of mixed samples were weighed and placed in a 10 mL sampling bottle of a solid-phase micro-extraction instrument (Supelco Co., America). A manual sampler equipped with 2 cm - 50/30 μm DVB/CAR/PDMS StableFlex fibre head was inserted. The sample was heated at 120°C for different times (0, 15 and 45 min), and then headspace was sampled for 45 min. The extractor was rapidly withdrawn and inserted into the gas chromatograph (HP6890/5975C, Agilent Co.) at the inlet (tem-perature: 250°C). The sample was then heated for about 3 min.

Gas chromatography–mass spectrometry was used to measure the flavour components in mashed potatoes. The chromatographic column used was ZB-5MSI 5% phenyl-95% dimethylpolysiloxane (30 m × 0.25 mm × 0.25 μm) fused silica capillary columns. For gas chromatography pesticide separation, the initial oven temperature was set to 40°C, maintained for 2 min, and then increased to 240°C at a rate of 5°C min−1. The injector temperature was set to 25°C. The pre-column pressure was 7.62 psi, and the carrier gas (He, 99.999%) flow was 1.0 mL min−1. The mass spectrometer detector was operated in electron impact ionisation mode at 70 eV collision energy with a 1 min solvent delay to prevent filament damage to the ion source. The tem-perature of the ion source, quadrupole rod, and transfer line was set to 230°C, 150°C, and 280°C, respectively. For qualitative analysis, mass detection was set in scan mode from 29 - 500 mass/charge (m/z), and scanning interval was 1 s. For quantitative analysis, selected ion monitoring mode was used. Each peak in the total ion flow chart was retrieved by mass spectrometry data system and checked with NIST2002 standard spectrum library. Volatile chemical components were determined. The relative mass fraction of the chemical components was measured by peak area normalisation method.

Model establishment for evaluating the flavour components of mashed po-tatoes

Principal component analysis is one of the multivariate statistical analysis methods that can select few important variables from multiple var-iables by linear transformation (Nguyen *et al*., 2018; Pastore *et al*., 2018). According to the correlation coefficient, the correlation matrix was listed, the characteristic roots and their corresponding eigenvectors were obtained, and several larger characteristic roots were selected to let their cumulative con-tribution rate exceed 90%. The concrete steps were as follows (Johnson *et al*., 1996):

i. *m* variables of *n* samples. The principal component is a linear com-bination of primordial variables. The original variables X_1, X_2 ... X_m are integrated into K $(k < m)$ variables (F_1, F_2, ... F_k), F_1, F_2, … F_k, which represent first, second, and Kth principal components.

ii. The variance contribution rate of different eigenvalues β_i (i = 1, 2, … k) was used as the weighted coefficient, and the comprehensive evaluation function $F = \beta_1 F_1 + \beta_2 F_2 + ... + \beta_k F_k$ was used to calculate the scores of each sample. Finally, the main flavour compounds of mashed potatoes were evaluated.

Sensory evaluation method

Using the comprehensive scoring method, the full score was 10 points, of which the hardness was 2 points, the adhesiveness was 2 points, the co-hesiveness was 2 points, and the aroma and taste were 4 points. Ten pro-fessional experts scored the parameters, and the average score served as the final score. The sensory evaluation indicators of the products were not shown.

Statistical analyses

Experimental data were plotted using Origin 8.0 and Microsoft Excel 2003, and each experiment was repeated three times (n = 3). The results were expressed as mean ± standard deviation.

Results and discussions

Texture determination and analysis of mashed potato

The texture characteristics of the mashed potatoes were determined by TA-XT2i texture analyser at room temperature. According to Table 1, the texture characteristics of mashed potatoes from different varieties of pota-toes varied under the same conditions. Zdb and Andover performed better in hardness, elasticity, cohesiveness, tackiness and chewiness, but poorly in adhesion. These qualitative indices showed that mashed potatoes prepared from Zdb and Andover exhibited stiff texture and poor fluidity and adhesion. Therefore, comparatively large masticatory power was needed when eating. However, Hmr and Hbs performed better in adhesion, but poorly in hardness, elasticity, cohesiveness, tackiness and chewiness. Thus mashed potatoes made from Hmr and Hbs exhibited soft texture, and good fluidity and

Table 1. Texture indices of different varieties of mashed potatoes.

Potato variety	Hardness (N)	Adhesion value (mJ)	Elasticity value (mm)	Cohesiveness (Ratio)	Tackiness (N)	Chewiness (mJ)
Zdb	83.42 ± 2.83[a]	0.48 ± 0.01[c]	4.76 ± 0.13[a]	0.29 ± 0.02[a]	24.17 ± 3.06[ab]	117.64 ± 4.84[a]
Andover	77.54 ± 2.74[b]	1.23 ± 0.10[b]	4.03 ± 0.14[b]	0.33 ± 0.03[a]	25.69 ± 1.12[a]	103.64 ± 3.02[b]
Norland	70.48 ± 0.55[c]	1.73 ± 0.11[b]	2.20 ± 0.39[c]	0.31 ± 0.02[a]	21.55 ± 1.21[bc]	44.29 ± 0.19[d]
Ls 3	69.60 ± 3.19[c]	1.74 ± 0.14[b]	4.05 ± 0.17[b]	0.29 ± 0.02[a]	20.37 ± 1.95[c]	81.61 ± 1.20[c]
Hei Meiren	42.10 ± 3.96[e]	3.65 ± 0.71[a]	1.26 ± 0.13[d]	0.08 ± 0.01[b]	3.50 ± 0.36[d]	4.41 ± 0.77[f]
Hong Baoshi	51.27 ± 1.38[d]	3.39 ± 0.46[a]	1.90 ± 0.28[c]	0.11 ± 0.04[b]	6.30 ± 1.14[d]	14.97 ± 1.21[e]

Data are means ± standard deviation. Data with different superscript letters in the same column indicate significant difference.

adhe-sion capability, so a little masticatory power was enough when eating. While mashed potatoes made from Norland and Ls 3 demonstrated moderate hardness, fluidity, and adhesion capability.

Mashed potatoes are a semi-solid food which exhibits both solid and fluid properties. It is not only a multi-component system containing many macromolecules but also a viscoelastic system. It has both the viscous characteristics of a pure viscous fluid and the elastic characteristics of a pure elastic solid. Mashed potatoes with excellent quality are often lubricated at the entrance, moderately soft and hard, neither sticky nor excessively fluidised (Álvarez *et al*., 2011; Canet *et al*., 2011). In the present work, the texture characteristics of mashed potatoes prepared from six different varieties were studied. The experimental results showed that the texture characteristics of mashed potatoes made by varieties of potatoes were different, which was consistent with the experimental results of most researchers (Jarvis and Duncan, 1992; Canet *et al*., 2011). This is mainly due to the different types and contents of the substances contained in different varieties of potatoes. In the present work, it was found that amylose content in Zdb and Andover was higher among the six varieties (data not shown). Amylose has good film formation and strength, and its adhesion and stability are worse than that of amylopectin. When mashed potatoes were prepared from these two kinds of potatoes, the hardness and elasticity were good, but the fluid properties were poor.

Analysis of flavour compounds of mashed potato for different cooking times

During mashed potatoes preparation, cooking time is the main factor affecting its flavour compounds. Figure 1 shows the total ion chromatogram of different varieties of mashed potatoes subjected to different cooking times (0, 15 and 45 min). Random Xcalibur workstation NIST2002 standard spec-trum library was used to automatically retrieve each component of mass spectrometry data. Inspection results were checked and confirmed, and the relative content of each component was calculated by area normalisation method (Baumann *et al*., 2000). Figure 1 shows that the same varieties of mashed potatoes' content of flavour compounds increased with cooking times.

Zdb yielded ten kinds of flavour compounds, mainly consisting of alcohols (75.14%), in 0 min; 19 kinds of flavour compounds, mainly aldehyde (55.60%), and alcohols (17.29%), in 15 min; and 39 kinds of flavour com-pounds, mainly alkanes (34.39%), alcohols (11.06%), and aldehyde (9.67%), in 45 min.

Andover yielded 12 kinds of flavour compounds, mainly alcohols (67.27%), and alkanes (23.20%), in 0 min; 27 kinds of flavour compounds, mainly alcohols (62.73%), and alkanes (15.17%), in 15 min; and 40 kinds of flavour compounds, mainly alkanes (37.45%), aldehydes (19.41%), and al-cohols (12.79%), in 45 min.

Norland yielded ten kinds of flavour compounds, mainly alcohols (84.80%), in 0 min; 26 kinds of flavour compounds, mainly aldehydes (44.13%), alcohols (29.82%), and furans (10.69%), in 15 min; and 44 kinds of flavour compounds, mainly aldehydes (42.01%), alkanes (18.34%), and fu-rans (15.59%), in 45 min.

Ls 3 yielded nine kinds of flavour compounds, mainly alcohols (49.55%), and other substances (39.19%), in 0 min; 27 kinds of flavour compounds, mainly alkanes (44.98%), alcohols (25.64%), and aldehydes (21.53%), in 15 min; and 46 kinds of flavour compounds, mainly aldehydes (40.23%), alcohols (29.56%), and furans (12.25%), in 45 min.

Hmr yielded 13 kinds of flavour compounds, mainly aldehydes (83.04%), and alcohols (10.06%), in 0 min; 19 kinds of flavour compounds, mainly aldehydes (67.35%), and alkanes (10.04%), in 15 min; and 42 kinds of flavour compounds, mainly alkanes (10.22%), alcohols (12.94%), and al-dehydes (55.84%), in 45 min.

Hbs yielded 13 kinds of flavour compounds, mainly aldehydes (86.45%), in 0 min; 28 kinds of flavour compounds, mainly alcohols (17.34%), and aldehydes (59.04%), in 15 min; and 37 kinds of flavour compounds, mainly aldehydes (38.56%), alcohols (14.38%), and alkanes (10.37%), in 45 min.

Different varieties of potatoes yielded different kinds of flavour compounds at the same cooking time.

Results of principal component analysis

The results of the various components of different potato varieties cooked for 45 min are shown in Table 2. Eight kinds of aroma components in six varieties were used to structure a 6 × 8 matrix, and its principal component was analysed using SPSS software. The eigenvalues of correlation matrix and the total variance explained are shown in Table 3. It is apparent that the contribution rates of first, second, and third principal components were 58.187%, 18.474%, and 15.978%, respectively. The cumulative contribution rate of the first three principal components could reach 92.639%, indicating that the first three principal components could objectively reflect the infor-mation of the original variable.

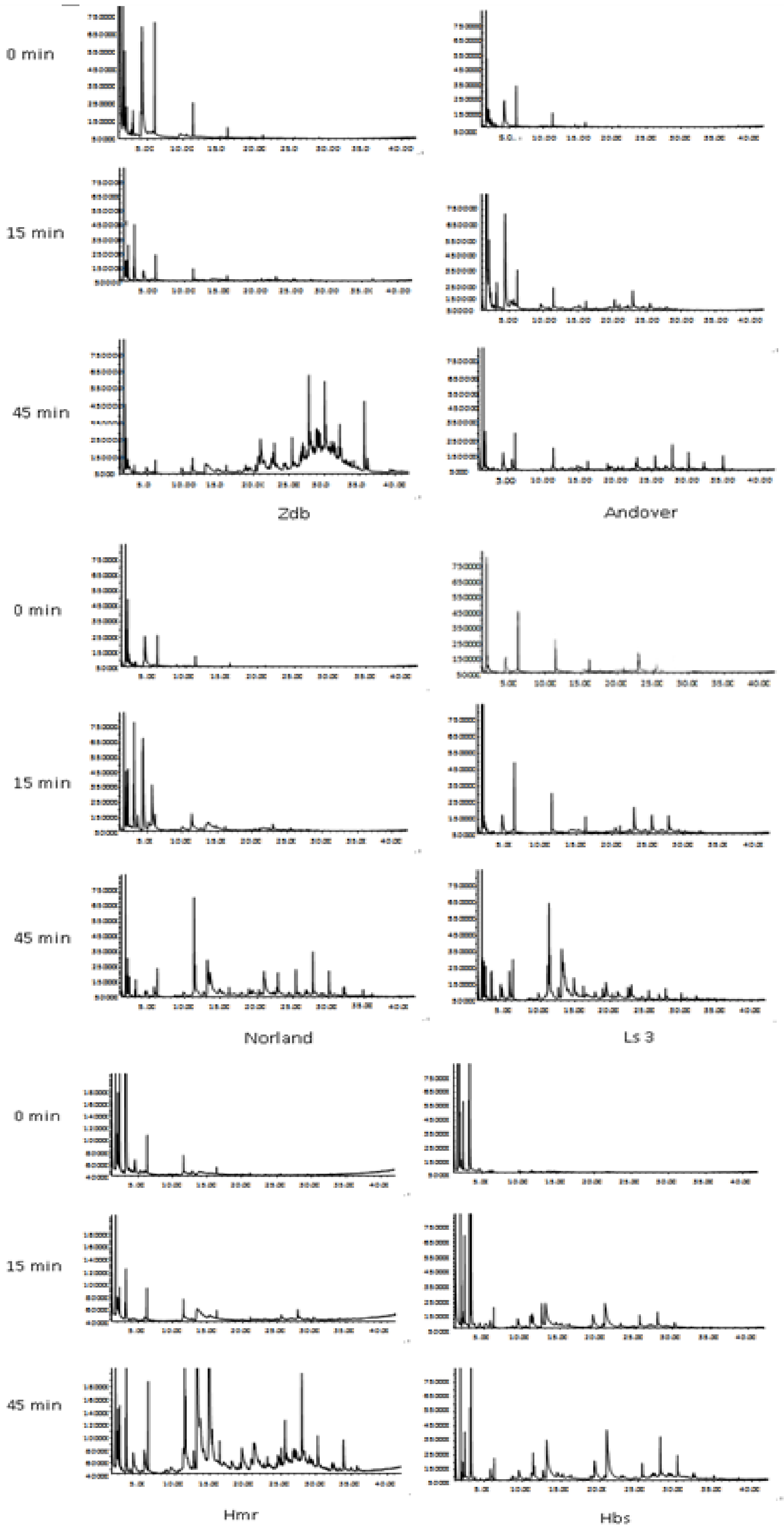

Figure 1. Total ionic atlas of different potato varieties at different cooking times.

Table 2. Results of the various components of different potato varieties cooked for 45 min.

Potato variety	Alkanes	Alcohols	Aldehyde	Alkenes	Furans	Esters	Ketones	Others
	X_1(%)	X_2(%)	X_3(%)	X_4(%)	X_5(%)	X_6(%)	X_7(%)	X_8(%)
Y1(Zdb)	34.392	11.063	9.667	1.387	1.838	4.303	-	3.728
Y2(Andover)	37.448	12.791	19.405	2.555	2.140	8.581	-	4.125
Y3(Norland)	18.338	3.885	42.055	1.339	15.585	1.165	0.107	1.071
Y4(Ls 3)	5.187	29.564	40.255	1.394	12.248	0.384	-	2.410
Y5(Hmr)	10.221	12.939	55.837	0.281	7.108	0.422	1.728	1.981
Y6(Hbs)	10.372	14.377	38.563	0.358	0.244	0.600	0.493	2.990

Table 3. Eigenvalues of principal components and their contribution and cumulative contribution.

Principal Components	Total Variance Explained					
	Initial Eigenvalues			Extracting Sums of Squared Loading		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.655	58.187	58.187	4.655	58.187	58.187
2	1.478	18.474	76.661	1.478	18.474	76.661
3	1.278	15.978	92.639	1.278	15.978	92.639
4	0.488	6.100	98.739			
5	0.101	1.261	100.000			
6	2.979E-16	3.724E-15	100.000			
7	1.654E-16	2.067E-15	100.000			
8	-3.948E-16	-4.935E-15	100.000			

Extraction method: principal component analysis.

Table 4. Eigenvectors and loading matrix.

Flavour compounds	F1		F2		F3	
	Eigenvectors	Loading matrix	Eigenvectors	Loading matrix	Eigenvectors	Loading matrix
X_1(Alkanes)	0.427	0.922	-0.010	-0.012	-0.321	-0.363
X_2(Alcohols)	-0.073	-0.157	0.069	0.084	0.853	0.964
X_3(Aldehyde)	-0.433	-0.934	-0.017	-0.021	-0.059	-0.067
X_4(Alkenes)	0.368	0.794	0.433	0.526	0.031	0.035
X_5(Furans)	-0.254	-0.548	0.662	0.805	-0.125	-0.141
X_6(Esters)	0.435	0.938	-0.005	-0.006	-0.113	-0.128
X_7(Ketones)	-0.287	-0.620	-0.505	-0.614	-0.213	-0.241
X_8(Others)	0.391	0.844	-0.338	-0.411	0.303	0.343

Extraction method: principal component analysis.

Table 4 shows that the first principal component was $F_1 = 0.427X_1 - 0.073X_2 - 0.433X_3 + 0.368X_4 - 0.254X_5 + 0.435X_6 - 0.287X_7 + 0.391X_8$, with a contribution rate of variance information of 58.187% and mainly reflecting the variation information on esters, alkanes, aldehydes, and other substances. The second principal component was $F_2 = -0.010X_1 + 0.069X_2 - 0.017X_3 + 0.433X_4 + 0.662X_5 - 0.005X_6 - 0.505X_7 - 0.338X_8$, with a contribution rate of variance information on 18.474% and mainly reflecting variation information of furans, ketones, and alkenes. The third principal component was $F_3 = -321X_1 + 0.853X_2 - 0.059X_3 + 0.031X_4 - 0.125X_5 - 0.113X_6 - 0.213X_7 + 0.308X_8$, with a contribution rate of variance information of 15.978% and mainly reflecting the variation information on alcohols and alkanes.

Table 4 shows further that the first principal components were highly relevant with alkanes and aldehydes, relevant with other substances, and highly negatively relevant with esters. The second principal components were highly relevant with furans and alkenes and highly negatively relevant with ketones. While the third principal components were highly relevant with al-cohols and negatively relevant with alkanes. The 76.661% total variance contribution originated from the first and second principal components. Table 4 also shows that the largest contribution to the first principal component was from esters, with a load of 0.938, followed by alkanes and other substances, with loads of 0.922 and 0.844, respectively. Therefore, the first principal components represented esters, alkanes and other substances. The most important contribution to the second principal component was from furans and alkenes, with loads of 0.805 and 0.526, respectively. Therefore, second principal component represented furans and alkenes. The least contribution to the first principal components was from aldehydes, with a load of 0.934, while the smallest contribution to the second principal component was the ketones, with a load of 0.614.

Following standardisation, the main components were divided as shown in Table 5. The highest score in the first principal component was Y2, indicating that Andover obtained the highest score among all potato varieties. The highest score in the second principal component was Y4, when Ls 3 reached the highest score among the potatoes. The highest score in the third principal component was Y5, showing that Hmr obtained the highest score among the potatoes.

Table 5. Principal component scores after standardization.

Potato variety	F1	F2	F3
Y1(Zdb)	1.0577	-0.3604	-1.4686
Y2(Andover)	1.3775	-0.1555	-0.8880
Y3(Norland)	-0.0593	-1.2112	0.4626
Y4(Ls 3)	-1.0481	1.8327	0.3553
Y5(Hmr)	-0.6696	-0.1380	1.2844
Y6(Hbs)	-0.6582	0.0325	0.2544

According to the aroma quality evaluation model established in sec-tion *"Model establishment for evaluating the flavour components of mashed potato"*, the evaluation scores of mashed potatoes from different potato va-rieties were calculated, and the results are shown in Table 6. Y2 obtained the highest score among different potato varieties, followed by Y1, Y4, Y6, Y3, and Y5. To test the evaluation effect of aroma quality evaluation model, sensory evaluation of mashed potatoes from different varieties was con-ducted. The results of sensory experiments are not shown. Y2 yielded the highest score, followed by Y1, Y4, Y3, Y6, and Y5. This trend was basically consistent with the evaluation indices of aroma quality.

Table 6. Aroma and sensory evaluation of different mashed potato varieties.

Potato variety	Aroma evaluation		Sensory evaluation	
	Score F	Order	Score (Point)	Order
Y1(Zdb)	10.251	2	7.7	2
Y2(Andover)	11.423	1	8.2	1
Y3(Norland)	1.843	5	6.7	4
Y4(Ls 3)	2.425	3	7.4	3
Y5(Hmr)	0.076	6	6.4	6
Y6(Hbs)	2.212	4	6.5	5

Comprehensive analysis

Flavour components are an important indicator for evaluating the quality of mashed potatoes. The mashed potatoes will produce a bad flavour like paper during storage, which is a serious problem in the food supply system. Therefore, it is necessary to determine the flavour components of mashed potatoes. In the present work, the flavour components of different varieties of mashed potatoes under different cooking times were tested by headspace solid phase micro-extraction and gas chromatography-mass spectrometry. As far as we know, this is a convenient and fast new method to detect the flavour components of mashed potatoes. And this is a relatively comprehensive analysis of the flavour components to the different varieties of potatoes under different cooking times. Based on this, we used principal component analysis to process the experimental results. The experimental results showed that esters, alkanes, aldehydes, furans and other substances were the main flavour components, which were consistent with many re-searchers (Petersen *et al*., 1999). Those flavours which contained both beneficial and some unpleasant flavours work together to create a unique flavour of mashed potatoes. Some flavour components, such as aromatic substances, alcohols, esters, etc., made the mashed potato have a unique aroma. However, some furans and a small part of aldehydes will produce an unpleasant smell of mashed potatoes. Finally, we established the aroma evaluation model of mashed potatoes based on the results of principal component analysis and we had evaluated their sensory quality. The ex-perimental results showed that the sensory evaluation model was consistent with the aroma evaluation model.

Conclusion

Among six varieties of mashed potatoes, Zdb and Andover exhibited hard texture, Norland and Ls 3 showed moderate texture, and Hmr and Hbs had soft texture. The esters, alkanes, aldehydes, furans and other substances were the main flavour substances in the chosen mashed potatoes. Andover yielded the highest score in the established aroma quality evaluation model, followed by Zdb, Ls 3, Hbs, Norland, and Hmr, which were basically con-sistent with sensory evaluation.

Acknowledgement

The authors gratefully acknowledge the financial support received from the Institute of Biotechnology, Guizhou Academy of Agricultural Sciences in China. The present work was also supported by the National Key Research and Development Plan of China (2016YFD0401304-03), National Science Foundation of China (No.31860461), Scientific and Technic Major Special Projects of Guizhou Province, China (2014 – 6016), and Basic Research Program of Guizhou Province (2017 – 1179).

References

Álvarez, M. D., Fernández, C. and Canet, W. 2005. Effect of freezing/thawing conditions and long-term frozen storage on the quality of mashed potatoes. Journal of the Science of Food and Agriculture 85(14): 2327–2340.

Álvarez, M. D., Fernández, C., Jiménez, M. J. and Canet, W. 2011. Texture of extra virgin olive oil-enriched mashed potatoes: sensory, instrumental and structural relationships. Journal of Texture Studies 42(6): 413–429.

Bagri, D. S., Upadhyay, D. C., Jain S. K. and Upadhyay, C. P. 2018a. Bio-technological improvement of nutritional and therapeutic value of cultivated potato. Frontiers in Bioscience 10: 217–228.

Bagri, D. S., Upadhyaya, D. C., Kumar, A. and Upadhyaya, C. P. 2018b. Overexpression of PDX-II gene in potato (*Solanum tuberosum* L.) leads to the enhanced accumulation of vitamin B6 in tuber tissues and tolerance to abiotic stresses. Plant Science 272: 267–275.

Baumann, C., Cintora, M. A., Eichler, M., Lifante, E., Cooke, M., Przyborowska, A. and Halket, J. M. 2000. A library of atmospheric pressure ionization daughter ion mass spectra based on wideband excitation in an ion trap mass spectrometer. Rapid Communications in Mass Spectrometry 14(5): 349–356.

Burlingame, B., Mouillé, B. and Charrondière, R. 2009. Nutrients, bioactive non-nutrients and anti-nutrients in potatoes. Journal of Food Compo-sition and Analysis 22(6): 494–502.

Canet, W., Fernández, C. and Alvarez, M. D. 2011. Functionality of amidated low-methoxyl pectin and xanthan gum blends on the texture and color of mashed potatoes. Journal of Food Processing Engineering 34(3): 746–776.

Food and Agricultural Organization of the United Nations (FAOSTAT). 2015. FAOSTAT statistical database. Retrieved from FAO website: http://www.fao.org/statistics/en/

Gancarz, M. 2018. At harvest prediction of the susceptibility of potato varie-ties to blackspot after impact over long-term storage. Postharvest Biology and Technology 142: 93–98.

Glusac, J., Davidesko-Vardi, I., Isaschar-Ovdat, S., Kukavica, B. and Fishman, A. 2018. Gel-like emulsions stabilized by tyrosi-nase-crosslinked potato and zein proteins. Food Hydrocolloids 82: 53–63.

Jarvis, M. C. and Duncan, H. J. 1992. The textural analysis of cooked potato. 1. physical principles of the separate measurement of softness and dryness. Potato Research 35(1): 83–91.

Johnson, J. R., Braddock, R. J. and Chen, C. S. 1996. Flavour losses in orange juice during ultrafiltration and subsequent evaporation. Journal of Food Science 61(3): 540–543.

Lu, R., Yang, Z., Song, H., Zhang, Y., Zheng, S., Chen, Y. and Zhou, N. 2016. The aroma-active compound, acrylamide and ascorbic acid contents of pan-fried potato slices cooked by different temperature and time. Journal of Food Processing and Preservation 40(2): 183–191.

Majeed, A., Chaudhry, Z. and Muhammad, Z. 2014. Changes in foliar gly-coalkaloids levels of potato (*Solanum tuberosum*) triggered by late blight disease severity. International Journal of Agriculture and Biol-ogy 16(3): 609–613.

Miao, W., Hatab, S., Gu, Y., Wang, L., Xu, X. and Pan, S. 2018. Rheological, sensory, and microstructural properties of fresh and frozen/thawed mashed potatoes enriched with different proteins. CyTA - Journal of Food 16(1): 113–121.

Muhammad, S., Shahbaz, M., Iqbal, M., Wahla, A. S., Ali, Q., Shahid, M. T. S. and Tariq, M. S. 2013. Prevalence of different foliar and tuber dis-eases on different varieties of potato. Advancements in Life Sciences 1(1): 64–70.

Nguyen, T. H., Nguyen, T. M. H., Kang, B., Cho, B., Park, Y., Jung, Y. M. and Yang, I.-S. 2018. Structural symmetry changes in SmB6-2D correla-tion spectroscopy and principal component analysis. Journal of Mo-lecular Structure 1165: 84–89.

Pastore, C., Barca, E. and Del Moro, G., Di Laconi, C., Loos, M., Singer, H. P. and Mascolo, G. 2018. Comparison of different types of landfill leachate treatments by employment of nontarget screening to identify residual refractory organics and principal component analysis. The Science of the Total Environment 635: 984–994.

Petersen, M. A., Poll, L. and Larsen, L. M. 1999. Identification of compounds contributing to boiled potato off-flavour ('POF'). LWT - Food Science and Technology 32(1): 32–40.

Rafiq, S. M. and Ghosh, B. C. 2017. Effect of potato incorporation on the physico-chemical, textural and sensory properties of processed cheese. Journal of Food Measurement and Characterization 11(2): 776–780.

Reyniers, S., De Brier, N., Matthijs, S., Brijs, K. and Delcour, J. A. 2018. Impact of physical and enzymatic cell wall opening on the release of pre-gelatinized starch and viscosity forming potential of potato flakes. Carbohydrate Polymers 194: 401–410.

Yusuph, M., Tester, R. F., Ansell, R. and Snape, C. E. 2003. Composition and properties of starches extracted from tubers of different potato vari-eties grown under the same environmental conditions. Food Chem-istry 82(2): 283–289.