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RESEARCH ARTICLE

Sweet potato and potato residual flours as potential nutritional and healthy food material

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Abstract

In this study, the proximate composition, mineral content and amino acid composition of starch processing residues from 10 cultivars of sweet potato and 10 cultivars of potato were determined, and the nutritional and health-related values of these residues were investigated. The residual flours contained 20.63–31.48 g and 17.14–28.57 g rich dietary fiber per 100 g dry weight for sweet potato and potato, respectively, as well as mineral elements, including potassium, ferrum, zinc and copper. The highest limiting amino acid score (AAS) of the almost balanced amino acid composition were observed to be 71.07 and 57.96 for sweet potato and potato residues, respectively. A grey relational analysis showed that the nutritional values of Jishu 4 at 0.7519 and LT-5 at 0.7281 were the highest among the sweet potato and potato residues, respectively. The evaluation of the sweet potato/potato residues, the by-products of the starch industry, based on recommended daily intake (RDI) standards, indicated that the residues have potential nutritional and health-related food values.

Keywords: sweet potato residue, potato residue, component analysis, comprehensive nutritional value, grey relational analysis

1. Introduction

During sweet potato and potato starch production, large amounts of residues are produced. Their low utilization rate causes heavy environmental pollution, resulting in a serious problem that is threatening the starch industry in China. Some studies have focused on using the starch residues as economical resources for biomass production (Singh *et al*. 1991; Klingspohn *et al*. 1993; Hashem and Darwish 2010; Yokoi *et al*. 2001), animal feed production (Serena *et al*. 2009; Christian *et al*. 2011) and effective component extraction (Nado *et al*. 1994; Yoshimoto *et al*. 2005; Mei *et al*. 2010; Zhang and Mu 2011). Each alternative use could present a good solution to manage these residues.

Sweet potatoes, potatoes and their flour products have good nutritional values (Laurie *et al*. 2013; McGill *et al*. 2013; Shekhar *et al*. 2015). Additionally, the residues from starch extraction processes also possess many advantages, especially abundant dietary fiber, that can help reduce the risks of high blood pressure, cardiovascular disease and diabetes (Kaczmarczyk *et al*. 2012; Yao *et al*. 2014; Ma *et al*. 2015). Recently, studies have focused on using these residues in food production, such as gluten-free staple foods (Bastos *et al*. 2016; Rodrigues and Batista *et al*. 2016). Sweet potato and potato residues could be used directly and completely

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in food production as a new type of gluten-free material in the future. To achieve this goal, it is necessary to know the proximate composition, mineral contents, and nutritional and health-related values of the residues from the different sweet potato and potato cultivars. However, until now, limited information has been available on the nutritional values of these residues from the different sweet potato and potato cultivars.

Grey relational analysis (GRA) is widely used for analyzing various relationships among discrete data sets and multiple attribute decision making (MADM) problems, involving many areas, such as in material sciences, logistics management, and manufacturing facilities (Samvedi *et al*. 2012). Lin *et al*. (2004) used GRA combined with the Taguchi method for converting the optimization of the multiple performance characteristics into grey relational grades to realize the optimization of turning operations. Kuo *et al*. (2008) proposed using GRA to solve MADM problems. In their study, two cases were analyzed by GRA, and a data envelopment analysis was used to confirm the feasibility of the GRA. The GRA was efficient for solving MADM problems. Çaydaş and Hasçalık (2008) used a GRA to determine the best factor level condition from 16 experimental runs based on the Taguchi method. Palanikumar *et al*. (2012) also used the Taguchi method and GRA to obtain the optimization of drilling parameters. Hu *et al*. (2016) used a GRA to establish relationships between antioxidant activities and chemical fingerprints to identify key bioactive compounds. Selecting and ranking different cultivars according to multiple nutritional indicators can also be regarded as an MADM problem; therefore, we employed a GRA to solve this problem.

In this study, 10 sweet potato and 10 potato cultivars that are mainly used for starch production in China were collected. Their proximate compositions (moisture, total starch, ash, crude protein, lipid, total, insoluble and soluble dietary fiber), mineral contents and amino acid compositions of their residues were determined. Then, a comprehensive evaluation of the nutritional values of these sweet potato and potato residues were carried out by a GRA. Based on the weighted grey relational degree obtained from the GRA, the nutritional rankings of these sweet potato and potato residues were also obtained.

2. Materials and methods

2.1. Raw materials and sample preparation

Five cultivars of fresh sweet potatoes (Xushu 18, Xushu 22, Xushu 24, Xushu 27 and Shangshu 19) were obtained from the Sweet Potato Research Institute, Chinese Academy of Agricultural Sciences in Jiangsu Province, China. The other five cultivars of fresh sweet potatoes (Jishu 4, Jishu 98, Jishu 982, Jishu 25 and Jishu 65) were obtained from the Institute of Cereal and Oil Crop, Hebei Academy of Agriculture and Forestry Sciences, China. Ten cultivars of fresh potato (Xingjia 2, Yanshu 4, Yanshu 5, Zhongshu 5, Qingshu 9, Helan 7, Helan 212, LT-5, Kexin 1 and Kexin 13) were obtained from the Heilongjiang Beidahuang Agriculture Company Limited, China. All of the sweet potatoes and potatoes were starch-type cultivars and were harvested by the end of October 2015.

According to the starch extraction method of Deng *et al*. (2013), after washing, peeling, and pulping with HR1861/30 Juice Extractor (Philips, China), clean sweet potato and potato residues were obtained. Then, the fresh residues were blanched in hot tap water (sweet potato 70°C for 30 s; potato 60°C for 45 s) for enzyme deactivation, color-protection and sterilization, and dried (sweet potato 70°C; potato 60°C) for 24 h. The dried residues were ground into flour by a high-speed universal pulverizer (FW100, Tianjin, China) and passed through a 100-mesh sieve (aperture of ~150 μm). The flour was kept in zip-lock bags and placed in the dark at 4°C for further analyses.

2.2. Proximate composition analysis

Moisture, ash, protein, lipid, starch, total dietary fiber (TDF), insoluble dietary fiber (IDF), and soluble dietary fiber (SDF) were measured by AOAC official methods (2000). The moisture content was determined by drying the sample to a constant weight at 105°C (AOAC method 925.09). The ash content was determined by placing the sample in a muffle furnace at 550°C for 8 h (AOAC method 940.26). The protein content was determined by the Kjeldahl method, using a nitrogen-to-protein conversion factor of 6.25 (AOAC method 955.04). The lipid content was determined by the Soxhlet method (AOAC method 920.39). The starch content was determined by AOAC method 996.11; TDF, IDF and SDF were determined by digesting the sample with α-amylase, amyloglucosidase and protease, respectively (AOAC method 991.43). All analyses were performed in triplicate.

2.3. Mineral content analysis

The mineral content analysis was carried out by the method previously reported by Sun *et al*. (2011) with some modifications. Briefly, 0.25 g sample was weighed into a polytetrafluoroethylene digestion tube and 8 mL 65% (v/v) HNO_3 was added for pre-digestion. After 1 h, 30% (v/v) H_2O_2 was added and digested using a microwave digestion system (MARS 5, CEM Co., Matthews, NC, USA). The digested solution was diluted to 100 mL with Milli-Q water (Bedford, MA, USA) and stored at 4°C in plastic tubes for further analysis. Sixteen mineral elements were measured by