Analysis of Phenolic Compounds in Waste Potato Pulp and Evaluation of Antioxidant Activity

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Abstract. The efficient use of waste produced during food processing is crucial for mitigating environmental damage, as well as for enhancing value and diversifying goods. In the future, the proliferation of food processing factories will correspond with population growth, leading to an escalation in food waste and associated waste management issues. The collecting of garbage and its utilization in the manufacture of new products is crucial for human health, environmental degradation, and the national economy. Potatoes (*Solanum tuberosum* L., Solanaceae) are one of the most important staple crops grown worldwide and play a significant role in both human and animal nutrition. The health-promoting effects of potatoes have been observed in human cell cultures, human clinical studies, and experimental animals, including anti-inflammatory, anti-cancer, hypocholesterolemic, antidiabetic, and anti-obesity properties. In this study, the phenolic content of waste potato pulp obtained from a chip factory was analyzed by HPLC-MS after obtaining an ethanol extract suitable for green chemistry, and the determination of total phenolic content was evaluated. Antioxidant activity was also assessed by the DPPH radical scavenging effect. In the resulting waste pulp, caffeic acid, a phenolic compound, was detected. The total phenolic content, determined to be 134.614 ± 4.167 mg gallic acid equivalent (GAE) per gram of extract, appears to be consistent with the chemical basis of this high antioxidant activity. It was observed that the DPPH free radical scavenging test reached an inhibition level of over 80%. Based on the results obtained, it was concluded that the waste potato pulp from the chip factory has the potential to be recycled.

(This study was supported by TUBITAK 2209-A student project.)

Keywords: Potato pomace, HPLC-MS analysis, Phenolic compounds, Antioxidant activity.

A. M. Bozdoğan et al. (eds.), *Proceedings of the 5th International Conference on Research of Agricultural and Food Technologies (I-CRAFT 2025)*, Atlantis Highlights in Sustainable Development 8,
https://doi.org/10.2991/978-94-6239-666-1_22

1 Introduction

The accumulation of waste from food processing industries is one of the main environmental issues associated with modern food production. Reuse of such waste in the production of natural products rich in bioactive compounds contributes to environmental sustainability and offers new opportunities for the development of functional ingredients [1].

Potatoes (*Solanum tuberosum* L.), belonging to the Solanaceae family, are one of the most important staple crops worldwide, with a high nutritional and economic value [2]. They contain carbohydrates, proteins, minerals, and a wide range of phytochemicals including phenolic acids, flavonoids, and glycoalkaloids [3; 4]. These compounds are known to exert antioxidant, anti-inflammatory, and antidiabetic properties [5; 6].

Large amounts of potato waste are generated during industrial processing for products such as chips, fries, and starch. These residues, if not managed properly, can cause significant environmental pollution. Considering the high phenolic content of potatoes and their antioxidant potential, the valorization of such waste offers an opportunity to recover valuable bioactive components.

This study aimed to determine the phenolic composition and antioxidant activity of waste potato pulp obtained from a chip factory, using green extraction techniques and advanced chromatographic analysis (HPLC-MS).

2 Materials and Methods

2.1 . Materials

Waste potato pulp was collected from a chip production facility located in Mersin, Türkiye. All solvents and reagents used in the analysis were of analytical grade.

2.2 . Extraction Procedure

The collected waste pulp was shade-dried and ground. A total of 100 g of dried material was subjected to Soxhlet extraction with ethanol for 24 hours. The extract was evaporated under reduced pressure using a rotary evaporator and dried in a desiccator until constant weight. The dried extract was stored at +4°C until analysis.

2.3 . HPLC–MS Analysis

Phenolic compounds were analyzed using a Thermo ORBITRAP Q-EXACTIVE HPLC-MS system equipped with an ESI source. A Troyasil C18 HS column (150 × 3 mm, 5 µm) was used. The mobile phase consisted of water containing 1% formic acid (A) and methanol with 1% formic acid (B) under a gradient flow rate of 0.35 mL/min.

The ion source voltage was set to 3.80 kV, and the capillary temperature was maintained at 320°C. Caffeic acid was identified as the major phenolic compound in the extract.

2.4 Determination of Total Phenolic Content

The total phenolic content (TPC) was determined using the Folin–Ciocalteu method. Results were expressed as milligrams of gallic acid equivalent (mg GAE) per gram of extract.

2.5 Antioxidant Activity

The DPPH radical scavenging assay was used to assess antioxidant potential. Extracts at varying concentrations (0.025–0.25 mg/mL) were incubated with DPPH solution at 37°C for 30 minutes, and absorbance was measured at 450 nm. Results were expressed as percentage inhibition relative to the control.

3 Results

3.1 Extraction Yield

A total of 1.015 g of extract was obtained from 100 g of dried *Solanum tuberosum* waste pulp, corresponding to an extraction yield of 1.015%. The dried ethanol extract appeared as a dark brown, viscous residue after solvent evaporation and desiccation.

3.2 HPLC–MS Findings

The phenolic profile of *Solanum tuberosum* pulp extract was determined by HPLC–MS analysis. The chromatogram (Figure 1) revealed that caffeic acid was the major phenolic compound, with a concentration of 192.766 mg/L extract and a relative uncertainty of 3.74% (Table 1). Other phenolic and flavonoid compounds such as chlorogenic acid, (+)-catechin, (–)-epicatechin, ellagic acid, and sinapic acid were identified in minor amounts (Table 2).

Table 1. Identified compound and concentration in the potato extract.

Compound	Concentration (mg/L extract)	Relative uncertainty (%)
Caffeic acid	192.766	3.74

Table 2. Detected flavonoid and phenolic compounds in the potato extract.

Compound	Ionization mode	Presence
Apigenin	–	Not detected
Luteolin	–	Not detected
Quercetin	–	Not detected
Sinapic acid	+	Detected
Caffeic acid	+	Detected
(+)-Catechin	–	Not detected
(–)-Epicatechin	–	Not detected
Chlorogenic acid	–	Not detected
Ellagic acid	–	Not detected

3.3 Total Phenolic Content

The total phenolic content of the ethanol extract was calculated using the Folin–Ciocalteu assay and expressed as gallic acid equivalents (GAE). The TPC value was determined as 134.614 ± 4.167 mg GAE/g extract. This high phenolic content indicates the presence of abundant polyphenolic constituents contributing to the extract's antioxidant potential.

3.4 Antioxidant Activity

The antioxidant capacity of the *Solanum tuberosum* extract was evaluated by the DPPH free radical scavenging assay. The extract exhibited a dose-dependent increase in antioxidant activity (Figure 1). At a concentration of 0.025 mg/mL, approximately 20% inhibition was observed; this value increased to around 40% at 0.05 mg/mL. At concentrations of 0.2 mg/mL and above, inhibition levels exceeded 80%, after which a plateau was reached, indicating a saturation point in radical scavenging efficiency (Fig. 1). These findings demonstrate that the extract has strong antioxidant potential, attributed mainly to the hydroxylated phenolic structure of caffeic acid, which can effectively donate hydrogen atoms to neutralize free radicals. The results agree with previously reported antioxidant effects of potato peel and pulp extracts [7].

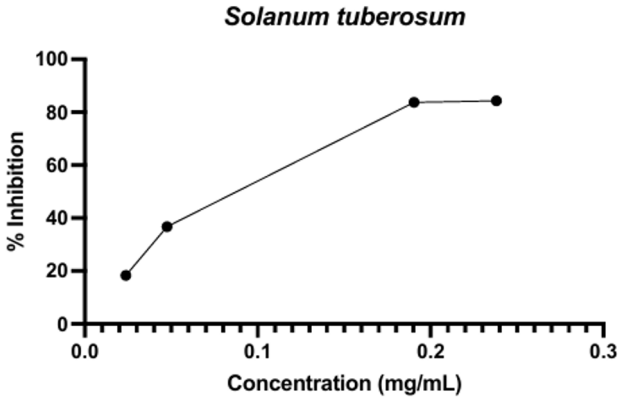

Fig. 1. DPPH activity result of *Solanum tuberosum* extract

4 Discussion and Conclusion

The presence of caffeic acid and a high total phenolic content explains the strong antioxidant activity of the *Solanum tuberosum* waste pulp extract. The plateau observed in DPPH inhibition indicates saturation in the radical scavenging process. These results show that waste potato pulp has considerable potential as a natural antioxidant source, suitable for applications in nutraceutical and food industries. Further studies involving fractionation and bioactivity-guided isolation are recommended to identify specific compounds responsible for the observed bioactivity.

Acknowledgments. This study was supported by the Scientific and Technological Research Council of Turkey (TÜBİTAK) within the framework of the 2209-A University Students Research Projects Support Programme (Project No: 1919B012466978).

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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