ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.2.1.P202

Review on Physical and Chemical Properties of Potato Protein and its Hydrolysate

Yurui Chen [1, a], Wanting Zhang [1, b], Rongrong Ma [1, c] ,Chao Mao [1, d *]

[1] College of Food Science and Engineering, Northwest A&F University, Yangling 712100, China.

[a] YuruiChen06@163.com, [b] WantingZhang@nwafu.edu.cn, [c] 563723130@qq.com,

[d] maochao@163.com

Abstract. Potato protein is generally recovered as a by-product from the potato pulp water in the potato starch industry. Due to the thermal treatment used during industrial recovery, the protein's solubility is reduced, resulting in poor functional properties and limiting its application in the food industry. To better understand the functional properties of water-soluble potato protein, this review summarizes the physical properties such as emulsification and foaming, as well as the chemical properties such as antioxidant activity and biological functions like cholesterol-lowering effects of potato protein and its hydrolysates.

Keywords: potato protein; emulsifying; foaming; antioxidant; cholesterol

1. Introduction

Potatoes are the fourth most important crop globally, after rice, wheat, and corn, and serve as one of the main raw materials for starch production in industry[1]. The starch industry produces a large amount of industrial wastewater, which contains high levels of COD due to the presence of nutrients such as proteins and polysaccharides. To reduce environmental pollution caused by this wastewater and lower the costs of wastewater treatment, attention has been given to recovering valuable substances from this waste[2]. The protein content in this wastewater is usually around 2%, making potato protein the most prominent target for recovery[3]. Potato protein has an excellent amino acid profile and is considered a nutritious source of dietary protein[4]. Although sulfur-containing amino acids are limiting in potato protein, it has higher lysine content compared to other grain proteins. Additionally, potato protein and its hydrolysates exhibit certain functional properties such as emulsification, foaming, and antioxidant activity, indicating its potential for use in the food industry[5]. The functional properties of potato protein, especially the soluble potato protein and its hydrolysates, were reviewed in this paper.

2. Physical Functions of Potato Protein

The physical functionality of potato protein is closely related to its extraction process. The thermal coagulation and acid precipitation used during protein recovery cause significant denaturation, leading to reduced protein solubility and poorer functional properties such as emulsification and foaming. Therefore, to study the functional properties of potato protein, less denatured potato protein needs to be used.

2.1 Emulsification Properties

Potato proteins are categorized into three types: patatin, protease inhibitors(PI), and high molecular weight (MW) proteins, which account for approximately 40%, 50%, and 10% of the total, respectively[6]. Patatin is a good emulsifier with foaming and gel forming ability and good stability[7]. At pH 4-5, potato protein exhibited better emulsifying properties than soybean protein, while at pH 6-8, soybean protein outperformed potato protein. As pH decreased from 8 to 4, the solubility of potato protein decreased, and its emulsifying activity also declined[8].Piao et al.[9] showed that without salt, the emulsifying activity of potato protein decreased as pH dropped from 8 to 5, which could be related to the fact that patatin, the most abundant protein in potato, has an

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.2.1.P202
isoelectric point of 4-5. As the pH decreases, the solubility of patatin decreases, and its emulsifying activity theoretically declines, suggesting that patatin may play a key role in emulsification. Van Koningsveld et al.[10] also found that emulsions made with patatin as the emulsifier were more stable than those made with other potato protein concentrates. However, contrary to previous findings, Van Koningsveld's study showed that potato protein exhibited better emulsifying stability at pH 3 than at pH 5 and 7, possibly due to different evaluation methods used.However, Ralet et al.[11] showed that after isolating and purifying potato protein using ion exchange resins, the emulsifying ability of the patatin-enriched fraction decreased, while the fraction enriched with protease inhibitors showed better emulsifying properties. The patatin-enriched fraction still contained some protease inhibitors, and their presence may cause instability in emulsions. Although the emulsifying properties of the patatin-enriched fraction were inferior to those of the protease inhibitor-enriched fraction, it showed better resistance to heat-induced particle aggregation in emulsions. Potato protein isolate shows an emulsifying activity index of 17.14 m2/g. Patatin has a maximum emulsifying activity index of 55.1 m2/g compared to PIs[12].Schmidt et al.[13] found that patatin displayed a higher emulsifying activity index and emulsifying stability index than protease inhibitors, likely because patatin has a higher concentration of surface-active groups, such as hydrophobic and hydrophilic regions that interact with the oil and water phases, thereby improving emulsification. In contrast, protease inhibitors may have a lower concentration or distribution of these surface-active groups, resulting in weaker emulsification. Patatin also exhibits better interfacial properties, such as lower interfacial tension and superior interfacial stability, contributing to the stability of emulsions. Lomolino et al.[14] studied the emulsifying activity of potato protein in the presence of κ-carrageenan under different pH conditions. In this study, stereomicroscopy was used to observe different emulsions, and the diameters of oil droplets were measured from microscopic images obtained using Axio Vision software. Based on stereomicroscopic analysis, the potato protein-κ-carrageenan complex showed the best emulsifying ability at pH 3.0, with uniform small oil droplets (30 μm) observed in the prepared emulsions.

2.2 Foaming Properties

Partsia and Kiosseoglou[15] studied the foaming properties of potato protein recovered using sodium carboxymethyl cellulose (CMC) as a precipitant and freeze-dried afterward. The results showed that potato protein concentrate (74.4% protein content) obtained by whipping had better foaming capacity and foam stability compared to egg white protein. Furthermore, the surface pressure of potato protein concentrate was higher than that of ovalbumin. When the solution was treated with a 12,000 Da molecular weight cut-off membrane to remove permeate components, the foaming capacity and foam stability of the potato protein decreased, indicating that small molecules play a role in foaming capacity and foam stability. Since CMC was not removed from the potato protein concentrate obtained by Partsia, it is possible that a complex formed between the potato protein and CMC, which may have contributed to foam formation and stability. Therefore, Vikelouda and Kiosseoglou[16] compared the foaming properties of potato protein in the presence and absence of CMC, showing that the foaming capacity of potato protein was higher than that of the potato protein-CMC complex, but the foam stability of the potato protein-CMC complex was superior to that of potato protein alone.If the lower protein content in the potato protein-CMC complex is considered, the foaming capacity of potato protein may not necessarily be superior to that of the potato protein-CMC complex.

Although the emulsifying properties of patatin-enriched acidic fractions are superior to the basic fractions containing 16-25 kDa protease inhibitors[17], the opposite is true for foaming properties. The basic fractions containing 16-25 kDa protease inhibitors have poor foaming capacity, while the acidic fractions enriched in patatin exhibit better foaming properties. The foaming capacity and foam stability of the acidic fraction are comparable to, or in some conditions (pH 5-7, 1 wt% NaCl concentration) superior to, egg white powder[18]. Patatin generally has good foaming performance in a mildly acidic to neutral pH range. Deviations from this pH range reduce foaming capacity and

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.2.1.P202
stability[19]. Additionally, increasing protein concentration from 0.1% to 1.0% (w/w) significantly increases foam volume by nearly 100%. However, further increases in protein concentration do not affect foaming capacity, which stabilizes at 250%. Foam stability is similar to foaming capacity, with a slight increase observed when protein concentration exceeds 1.0%. At a concentration of 0.1%, no foam remained after 30 minutes, while foam stability increased from 65% to 81% between concentrations of 1.0% and 10%[20].

2.3 Gelling Properties

There are few studies on the gelling properties of potato protein, both domestically and internationally. Løkra et al.[21] analyzed the rheological properties of potato protein at a higher concentration (9.5%) and observed no significant gel point, suggesting that the gelling ability of potato protein is weak. However, Piao Jinmiao et al.[22] studied the gelling properties of potato protein isolates and found that potato protein has certain gelling properties, with a minimum gelation concentration of 6 wt%. At pH 7.0, when the potato protein isolate with a concentration of 12 wt% was heated at 95°C for 15 minutes, a well-textured gel was obtained.

3. Chemical Functions

3.1 Antioxidant Activity of Potato Protein

Patatin contains several amino acids with radical-scavenging properties, including tryptophan, phenylalanine, methionine, cysteine, histidine, and tyrosine, which contribute to its antioxidant and angiotensin-converting enzyme (ACE) inhibitory activities[23].Hussain et al.[24] found that ultrasound treatment of patatin for 20 minutes increased its free radical scavenging activity by 23%.Liu et al.[25] studied the antioxidant activity of purified patatin and demonstrated that at appropriate concentrations, patatin has the ability to scavenge DPPH and hydroxyl radicals, reduce LDL oxidation, and inhibit dihydrorhodamine oxidation induced by peroxynitrite. However, DPPH assays are suitable for oil-soluble systems, while patatin is water-soluble, so water-soluble ABTS radicals may be more appropriate for evaluating its radical-scavenging ability. Wang and Xiong[26] studied the ability of potato protein to scavenge ABTS radicals and found that it was relatively weak. However, the researchers used potato protein with low solubility and high levels of denaturation, which may have affected the evaluation of its ABTS radical-scavenging ability.Pihlanto et al.[27] used less-denatured potato protein to study its ability to scavenge ABTS radicals, finding that potato protein extracted from potato sprouts had a 37.2% scavenging rate, while mature potato protein had only a 5.6% scavenging rate. However, their extracted potato protein also contained polyphenols, which are strong radical scavengers. Sun [28] also found that patatin is an effective antiproliferative agent capable of inhibiting the proliferation of B16 mouse melanoma cells.

3.2 Antioxidant Activity of Potato Protein Hydrolysates

Although patatin shows some antioxidant activity, the effect of industrial potato protein products is not ideal. Many studies have shown that enzymatic hydrolysis can improve the functional properties of proteins. Wang and Xiong[26]hydrolyzed industrial potato protein products using alcalase, and they observed a significant increase in protein solubility and antioxidant activity with increasing hydrolysis time. Enzymatic hydrolysis can convert potato protein isolate (PPI) into hydrolysates (PPIH) with different molecular sizes, charges, and physicochemical properties. PPIH has gained attention in recent years due to its antioxidant activity. For example, PPIH exhibits antioxidant activity, reducing Fe (II)/H_2O_2-induced oxidation of glutathione (GSH)[29]. Kudoh[30] and Kudo[31] et al.hydrolyzed potato protein using Amano P and trypsin, respectively, and found that the resulting potato protein hydrolysates inhibited linoleic acid oxidation in β-carotene-linoleic acid coupled oxidation and ferric thiocyanate-linoleic acid coupled oxidation systems. These findings suggest that potato protein hydrolysates could be potential antioxidants for use in food

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.2.1.P202
systems. However, there are few studies on the application of potato protein and its hydrolysates in real food systems. When potato protein hydrolysates were added as an antioxidant to beef patties and emulsified sausages[32], they inhibited fat oxidation, suggesting that they may also inhibit fat oxidation in food emulsions. Cheng et al.[33] demonstrated that adding potato protein hydrolysates to model food emulsions improved the oxidative stability of the emulsions. At lower degrees of hydrolysis, potato protein hydrolysates still contain a large number of potato protein particles, resulting in low utilization rates of potato protein.Kamnerdpetch et al. [34] used a combination of endogenous and exogenous protease systems to hydrolyze potato protein for 26 hours, achieving a degree of hydrolysis of 44%, far greater than the 22% achieved using a single flavorzyme (7%, w/w) and the 8% achieved using a single alkaline protease. Elahi et al.[35] also demonstrated through ABTS radical-scavenging assays that PPIH can protect C2C12 cells from H_2O_2-induced oxidation.

3.3 Other Functional Properties of Potato Protein Hydrolysates

Most studies on potato protein hydrolysates focus on their antioxidant properties, with fewer studies on other properties. Rahimi et al.[36] identified bioactive peptide sequences in potato protein hydrolysates and their fractions, showing potential for use as novel antidiabetic and antioxidant additives in new food formulations. Pihlanto et al.[27] also enzymatically hydrolyzed the protein-containing by-product slurry, potato pulp, and potato protein extracted from potatoes in the potato starch industry. The activity of the obtained potato protein hydrolysate in inhibiting ACE was also improved.

4. Biological Functions

Potato protein and its hydrolysates not only exhibit antioxidant activity in vitro but also show ACE inhibitory activity, with hydrolysis enhancing the ACE inhibitory activity of potato protein[30]. Animal experiments have shown that potato protein hydrolysates containing 5% protease inhibitors can catalyze the release of cholecystokinin receptors. By establishing an ob/ob obese mouse model, the experimental results after 28 days show that potato extracts can significantly inhibit obesity and type 2 diabetes[37]. Animal studies have shown that potato protein hydrolysates exhibit bioactivity in vivo. Sun et al.[38] evaluated the inhibitory effect of purple potato protein extract on DSS-induced colitis using a DSS-induced acute ulcer mouse model. The results showed that the purple potato extract improved the disease activity index of DSS-treated mice and reversed the loss of colon structure, mucosal damage, macrophage infiltration, and secretion of pro-inflammatory cytokines induced by DSS. It also restored the level of tight junction proteins in DSS-treated mice. Furthermore, the dietary potato protein hydrolysates enhanced the peroxisome proliferator-activated receptor-gamma coactivator-1 alpha (PGC-1α) signaling pathway, mitochondrial biogenesis, mitochondrial proteostasis, and protein folding ability. Piotr et al.[39] studied the protective effect of potato dietary fiber on acrylamide-induced toxicity in male mice. The results showed that acrylamide-induced changes altered the morphology and histology of the small intestinal wall, reducing proliferation, muscularis and submucosal thickness, villus length, fractal dimension, crypt depth, crypt number, and the absorptive surface of the small intestine.

On the contrary, apoptosis, hemoglobin adduct levels, epithelial staining intensity, the number of intestinal epithelial cells, villus epithelial thickness, and crypt width and parameters related to ganglia increased. However, in the intervention group, the addition of two types of potato dietary fiber eliminated the negative impact of acrylamide on the small intestinal wall but had no effect on the hemoglobin adduct level of acrylamide. Xu et al.[40] studied the in vivo immune function and antitumor activity of potato freeze-thaw solution. In the study, the potato freeze-thaw solution was fed to mice with ascites tumors pretreated with cyclophosphamide. The number of peripheral white blood cells, macrophage phagocytosis, lymphocyte transformation, and survival rate of mice were measured. The results showed that treating cyclophosphamide-injected mice with potato freeze-thaw solution for 10 days significantly increased the number of peripheral blood leukocytes,

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.2.1.P202
and treating for 20 days significantly enhanced peritoneal macrophage phagocytosis and lymphocyte transformation, thus proving the immune function and antitumor activity of potato freeze-thaw solution. Through previous research, it is known that potato extract can improve obesity caused by a high-fat diet. Based on this, Liu et al.[41] studied the mechanism of action of potato extract on high-fat diet-induced obesity in mice. The results showed that, unlike what is commonly observed with fat absorption inhibitors like orlistat, fecal fat content in potato extract-fed obese mice was reduced. Moreover, the intervention significantly improved high-fat diet-induced obesity, including weight gain, fat accumulation, adipocyte enlargement, insulin resistance, and hepatic steatosis. Improvements in hepatic steatosis were associated with the downregulation of nuclear factor kappa B activation in the livers of high-fat diet-fed mice. These findings suggest that potatoes have great potential as a dietary supplement for controlling weight and treating hepatic steatosis, with mechanisms potentially different from those of orlistat.

5. Conclusion and Outlook

In summary, potato protein is currently recovered as a by-product of the starch industry, but the thermal treatment used during protein recovery results in low solubility, often limiting its use to animal feed. However, potato protein is highly nutritious and a good source of dietary protein. Mild recovery methods that reduce protein denaturation could help retain the functional properties of potato protein. Potato protein consists of different components, and each component may exhibit different functional properties. Many studies suggest that patatin is the primary basis for the physical and biological activities of potato protein. Patatin is sensitive to changes in temperature and pH, performing better under neutral conditions, where it shows good emulsifying and foaming activities. Therefore, processing methods for potato protein should aim to minimize patatin denaturation. However, potato protein contains a large amount of protease inhibitors, and mild thermal treatment can retain some of their activity, which may affect food digestion and reduce the nutritional quality of potato protein. The activity of protease inhibitors can be inactivated by severe thermal treatment, but such treatment can damage the functional properties of potato protein. Enzymatic hydrolysis to inactivate protease inhibitors seems to be a better method, as it can preserve the nutritional quality of potato protein while improving its safety and biological functionality as a food additive.

References

[1] Chung, I.M.; Kim, J.K.; Jin, Y.I.; Oh, Y.T.; Prabakaran, M.; Youn, K.J.; Kim, S.H. Discriminative study of a potato (Solanum tuberosum L.) cultivation region by measuring the stable isotope ratios of bio-elements [J]. Food Chem. 2016, 212, 48 – 57.

[2] Waglay, A.; Karboune, S.; Alli, I. Potato protein isolates: Recovery and characterization of their properties [J]. Food Chem. 2014, 142, 373 – 382.

[3] Barta, J., Hermanova, V. , Divis, J.. Effect of low-molecular additives on precipitation of potato fruit juice proteins under different temperature regimes [J]. Journal of Food Process Engineering. 2008, 31, 533 – 547.

[4] Camire, M.E.; Kubow, S.; Donnelly, D.J. Potatoes and human health. Crit. Rev [J]. Food Sci. Nutr. 2009, 49, 823 – 840.

[5] Bashash, M.; Wang, P.G.; He, O.S. et alThe emulsifying capacity and stability of potato proteins and peptides: A comprehensive review [J]. Comprehensive Reviews In Food Science And Food Safety. 2024, 23(5), 70007.

[6] Fu, Y., Liu, W. N., Soladoye, O. P. Towards potato protein utilisation: Insights into separation, functionality and bioactivity of patatin [J]. International Journal of Food Science & Technology. 2020, 55(6), 2314 – 2322.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.2.1.P202
[7] Fu, Y., Alashi, A.M., Young, J.F., et al. Enzyme inhibition kinetics and molecular interactions of patatin peptides with angiotensin I-converting enzyme and renin [J]. International Journal of Biological Macromolecules. 2017,101, 207–213.

[8] Romero A, Beaumal V, David-Briand E，et al. Interfacial and Oil/Water Emulsions Characterization of Potato Protein Isolates [J]. J Agric Food Chem, 2011, 59(17):9466–9474.

[9] Piao, J.M; Du, F.H; Qi, B.Solubility and Emulsifying Properties of Potato Protein Isolate[J]. Food Science, 2009, 30(17):91–94.

[10] vanKoningsveld G A, Walstra P, Voragen A G J, et al. Effects of protein composition and enzymatic activity on formation and properties of potato protein stabilized emulsions [J]. J Agric Food Chem, 2006, 54 (17):6419–6427.

[11] Ralet M C, Gueguen J. Fractionation of potato proteins: solubility, thermal coagulation and emulsifying properties [J]. Lebensm Wiss Technol, 2000, 33 (5):380–387.

[12] M. Hussain, A. Qayum, X. Zhang, X. Hao, L. Liu, Y. Wang, et al. Improvement in bioactive, functional, structural and digestibility of potato protein and its fraction patatin via ultra-sonication [J].Lebensmittel-Wissenschaft und -Technologie, 2021,148.

[13] J.M. Schmidt, H. Damgaard, M. Greve-Poulsen, L.B. Larsen, M. Hammershøj Foam and emulsion properties of potato protein isolate and purified fractions [J].Food Hydrocolloids, 2018, 74, 367-378.

[14] Lomolino, G., Vincenzi, S., Zannoni, S., Marangon, M., De Iseppi, A., & Curioni, A. Emulsifying activity of potato proteins in the presence of κ -carrageenan at different pH conditions [J]. Food Chemistry, 2022, 13, 100232.

[15] Partsia Z, Kiosseoglou V. Foaming properties of potato proteins recovered by complexation with carboxymethylcellulose [J]. Colloids Surfaces B, 2001, 21, (1-3):69–74.

[16] Vikelouda, M.; Kiosseoglou, V., The use of carboxymethylcellulose to recover potato proteins and control their functional properties [J]. Food Hydrocolloids 2004, 18, (1):21–27.

[17] Cui Z M，Huang H S，Qin H H, et al. Isolation and Characterization of Potato Protein Fractions[J]. Food Science, 2011, 34(3):76–80.

[18] Ralet M C, Gueguen J. Foaming properties of potato raw proteins and isolated fractions [J]. Lebensm Wiss Technol, 2001, 34,(4):266–269.

[19] M. Hussain, A. Qayum, X. Zhang, X. Hao, L. Liu, Y. Wang, et al. Improvement in bioactive, functional, structural and digestibility of potato protein and its fraction patatin via ultra-sonication [J]. Lebensmittel-Wissenschaft und -Technologie, 2021, 148, 111747.

[20] E. Dachmann, V. Nobis, U. Kulozik, J. Dombrowski. Surface and foaming properties of potato proteins: Impact of protein concentration, pH value and ionic strength [J].Food Hydrocolloids, 2020, 107, 105981.

[21] Løkra S, Helland M H, Claussen I C, et al. Chemical characterization and functional properties of a potato protein concentrate prepared by large-scale expanded bed adsorption chromatography [J]. LWT-Food Sci Technol, 2008, 41(6):1089–1099.

[22] Pu, J.M; Du, F.H; Qi, B. Gelation Properties of Potato Protein Isolates [J]. Food Sci, 2009, 30(22):108–111.

[23] Elias, R.J.; Kellerby, S.S.; Decker, E.A. Antioxidant activity of proteins and peptides [J]. Crit. Rev. Food Sci. Nutr. 2008, 48, 430–441.

[24] Hussain M, Qayum A, Zhang X X， et al.Improvement in bioactive, functional, structural and digestibility of potato protein and its fraction patatin via ultra-sonication [J].LWT-Food Sci Technol, 2021, 148:111747.

[25] Liu Y W, Han C H, Lee M H, et al. Patatin, the tuber storage protein of potato (Solanumtuberosum L.), exhibits antioxidant activity in vitro [J]. J Agric Food Chem. 2003, 51 (15):4389–4393.

[26] Wang L L, Xiong Y L. Inhibition of lipid oxidation in cooked beef patties by hydrolyzed potato protein is related to its reducing and radical scavenging ability [J]. J Agric Food Chem, 2005, 53,(23):9186–9192.

ISSN:3007-9640 DOI: https://doi.org/10.70114/acmsr.2025.2.1.P202
[27] Pihlanto, A.; Akkanen, S.; Korhonen, H.J. ACE-inhibitory and antioxidant properties of potato (Solanum tuberosum). Food Chem. 2008, 109, 104–112.

[28] Sun Y, Jiang L Z, Wei D X. Partial characterization in vitro antioxidant and antiproliferative activities of Patatin purified from potato fruit juice[J]. Food & Function, 2013, 4(10): 1-10.

[29] Udenigwe, C.C.,Udechukwu, M.C., Yiridoe, C., et al. Antioxidant mechanism of potato protein hydrolysates against in vitro oxidation of reduced glutathione. J. Funct. Foods 2016, 20, 195–203.

[30] Kudoh K,Matsumoto M,Onodera S,et al. Antioxidative activity and protective effect against ethanol-induced gastric mucosal damage of a potato protein hydrolysate [J]. J Nutr Sci Vitaminol, 2003, 49 (6):451–455.

[31] Kudo K, Onodera S, Takeda Y, et al. Antioxidative activities of some peptides isolated from hydrolyzed potato protein extract [J]. J Funct Foods, 2009, 1(2):170–176.

[32] Nieto G, Castillo M, Xiong Y L, et al. Antioxidant and emulsifying properties of alcalase-hydrolyzed potato proteins in meat emulsions with different fat concentrations. Meat Sci, 2009, 83(1):24–30.

[33] Cheng Y, Xiong Y L, Chen J. Antioxidation and emulsifying property of hydrolyzed potato protein in soybean oil-in-water emulsions [J]. Food Chem, 2010, 120(1):101–108

[34] Kamnerdpetch C, Weiss M, Kasper C, et al. An improvement of potato pulp protein hydrolyzation process by the combination of protease enzyme systems [J]. Enzyme Microb Tech, 2007, 40(4):508–514.

[35] Elahi, R, Mu, T. H. High hydrostatic pressure (HHP)-induced structural modification of patatin and its antioxidant activities [J]. Molecules, 2017, 22(3):438

[36] Rahimi R, Gavlighi H A, Sarteshnizi R A, et al. In vitro antioxidant activity and antidiabetic effect of fractionated potato protein hydrolysate via ultrafiltration and adsorption chromatography[J]. LWT-Food Sci Technol, 2022, 154:112765.

[37] Sae Kwang Ku, Soo Hyun Sung, Jai Jun Choung, et al. Anti-obesity and anti-diabetic effects of a standardized potato extract in ob/ob mice[J]. Experimental and Therapeutic Medicine, 2016, 12(1):354-364.

[38] Sun Q, Bibi S, Xue Y S, et al. Dietary purple potato supplement attenuates DSS-induced colitis in mice: impact on mitochondrial function[J]. The Journal of Nutritional Biochemistry, 2024, 126:109585.

[39] Piotr D, Pauline H, Patrik K, et al. Potato fiber protects the small intestinal wall against the toxic influence of acrylamide[J]. Nutrition, 2012, 28(4):428-435.

[40] Xu G H, Shen J, Sun P, et al. Potato freeze-thaw solution enhances immune function and antitumor activity in vivo[J]. Oncology Letters, 2017, 14(5):6129-6134.

[41] Liu T G, Wu F, Chen K J, et al. Sweet potato extract alleviates high-fat-diet-induced obesity in C57BL/6J mice, but not by inhibiting pancreatic lipases[J]. Frontiers in Nutrition, 2022, 9: 1016020.