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Optimization and Valorization of Potato Starch for the Development of a Novel Functional Food Product

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ABSTRACT

Potato (*Solanum tuberosum* L.) is an economically important crop and a rich source of starch with considerable potential for functional and value-added food applications. The present study was undertaken to optimize the extraction of potato starch and explore its valorization potential through the development of a novel functional food product. Starch was extracted from potato using a controlled extraction process, and extraction conditions were optimized to achieve improved starch recovery and desirable functional quality. The optimized starch was subsequently characterized for its physicochemical and functional properties, including starch yield, moisture, ash, amylose content, swelling power, water absorption capacity, water solubility, and other technologically important attributes. The findings are expected to demonstrate the suitability of optimized potato starch for innovative food applications and provide a sustainable strategy for value addition, resource utilization, and development of nutritionally and technologically improved functional food products. This work may contribute to the advancement of potato-based food innovation and offer a promising pathway for the commercial utilization of potato starch as a versatile functional food ingredient.

Introduction

Potato (*Solanum tuberosum* L.) is an economically important food crop and a major source of dietary starch, making it an important raw material for both conventional food products and value-added food applications (Semeijn *et al.*, 2024; Muhammad Usman Arif *et al.*, 2025). Potato tubers accumulate substantial amounts of starch as their principal carbohydrate reserve, and the quantity and structural characteristics of this starch strongly influence potato processing quality and nutritional properties (Wang et al., 2024). Potato starch is particularly distinctive because of its large granule size, characteristic amylose–amylopectin composition, and relatively high phosphorus content, which collectively contribute to its unique physicochemical and functional behavior (Tahreem Fatima *et al.*, 2026; Wang *et al.*, 2024).

Starch functionality is closely associated with its molecular and granular structure, particularly the relative proportions and organization of amylose and amylopectin (Semeijn *et al.*, 2024). These structural characteristics influence important technological properties such as gelatinization, swelling, viscosity development, gel formation, solubility, and retrogradation, which ultimately determine the performance of starch in food-processing systems (Jia *et al.*, 2023; Semeijn *et al.*, 2024). Swelling power is particularly important because water absorption and granule expansion during heating influence starch viscosity, pasting behavior, gel strength, texture, and the overall quality of starch-based foods (Jia *et al.*, 2023). Similarly, amylose content can substantially affect starch gelatinization, gel formation, retrogradation, and digestibility, making it an important parameter for evaluating starch intended for functional food applications (Zhong *et al.*, 2023; Muhammad Nabeel Sharif *et al.,* 2025).

Despite these desirable characteristics, the functional performance of native potato starch can be affected by processing conditions and its limited resistance to heat, shear, and acidic environments, which may restrict its application in some formulated foods (Semeijn *et al.*, 2024; Alshammari *et al.*, 2026). Consequently, systematic optimization and characterization of starch extraction are essential for obtaining starch with improved recovery and consistent physicochemical and functional properties (Wang et al., 2024). The extraction procedure can influence starch purity, yield, moisture, ash, amylose content, swelling behavior, water absorption, and solubility, thereby affecting its subsequent performance in food formulations (Wang *et al.*, 2024; Salma Sabir *et al.*, 2026**)**.

The increasing interest in functional and health-oriented foods has further expanded the importance of starch modification and valorization strategies (Farooq & Yu, 2024; Muhammad Aleem *et al.*, 2026). Resistant starch, in particular, has received considerable attention because it escapes digestion in the small intestine and can undergo fermentation in the colon, producing short-chain fatty acids and potentially contributing to improved metabolic and gastrointestinal outcomes (Farooq & Yu, 2024). Physical processing approaches can modify starch structure and increase resistant starch formation while simultaneously altering its technological functionality, providing opportunities for the development of starch-based foods with improved nutritional characteristics (Farooq & Yu, 2024). Therefore, optimization of potato starch is not limited to maximizing extraction yield but also involves tailoring its functional properties according to the requirements of the intended food product (Aqsa Naseem *et al.,* 2026).

Valorization of potato starch provides an opportunity to convert an abundant agricultural resource into a higher-value functional ingredient for innovative food applications (Semeijn *et al.*, 2024; Tijjani *et al.,* 2025). Potato starch can contribute to desirable properties such as thickening, gel formation, viscosity development, texture modification, and processing stability, making it relevant to a broad range of food systems (Semeijn *et al.*, 2024). Recent research has also emphasized the potential of potato-derived resources within sustainable and circular food-processing systems, where improved utilization and development of value-added products can increase resource efficiency and reduce material losses (Tijjani *et al.*, 2025; Fiza Nasir *et al.,* 2026). This integrated approach is intended to establish a practical relationship between starch characteristics and food-product quality while demonstrating the potential of potato starch as a versatile functional ingredient. Such an approach can contribute to the development of innovative potato-based foods, improsved utilization of agricultural resources, and sustainable value addition within the food-processing sector (Semeijn *et al.*, 2024; Alshammari *et al.*, 2026).

Methodology

Fresh, mature, healthy potato tubers (*Solanum tuberosum* L.) were obtained from a local agricultural source and transported to the laboratory under hygienic conditions **(**Rabiya Javaid *et al.,* 2025). Tubers showing visible bruising, sprouting, fungal infection, or physical deterioration were excluded. The selected potatoes were thoroughly washed with potable water to remove adhering soil and foreign matter, followed by rinsing with distilled water. The cleaned tubers were peeled and cut into small, uniform pieces to facilitate efficient tissue disruption during starch extraction.

Extraction of Potato Starch

Potato starch was extracted through a wet extraction procedure based on established starch-isolation principles with suitable modifications. The prepared potato pieces were homogenized with distilled water using a laboratory blender to produce a uniform slurry. The slurry was filtered through a fine-mesh sieve or clean muslin cloth to separate fibrous tissue from the starch-containing liquid fraction. The filtrate was transferred into clean containers and allowed to stand for sedimentation of starch granules.

After sedimentation, the supernatant was carefully removed without disturbing the starch layer. The recovered starch was repeatedly washed with distilled water to remove soluble components and residual cellular material. Washing and sedimentation were continued until a relatively clean and white starch fraction was obtained. The starch was then recovered and dried under controlled conditions until constant weight was achieved. The dried material was gently ground, sieved to obtain a uniform powder, transferred into airtight containers, and stored under dry conditions until further analysis.

Optimization of Potato Starch Extraction

The extraction process was optimized by varying selected processing variables, including potato-to-water ratio, homogenization time, sedimentation time, and washing conditions. Different extraction treatments were evaluated to determine their effects on starch recovery and functional quality. Each treatment was conducted using the same basic extraction procedure while changing the selected optimization variables systematically.

Starch extraction yield was calculated as:

Starch yield (%) = [Weight of recovered dry starch / Weight of initial potato sample] × 100

The optimized extraction treatment was selected by considering maximum starch recovery together with desirable physicochemical and functional characteristics. The optimized starch was subsequently used for product development and comparative evaluation.

Physicochemical Characterization of Extracted Potato Starch

The optimized potato starch was characterized for moisture content, ash content, amylose content, swelling power, water absorption capacity, and water solubility. Moisture content was determined by drying a known quantity of starch to constant weight under controlled conditions. Ash content was determined by controlled incineration, and the remaining inorganic residue was expressed as a percentage of the original sample.

Amylose content was determined using an iodine-binding colorimetric method. A known quantity of starch was dispersed and reacted with iodine reagent, and the developed color was measured spectrophotometrically. Amylose concentration was calculated using a suitable calibration curve.

Swelling power was determined by heating a known amount of starch with distilled water under controlled conditions, followed by centrifugation and removal of the supernatant. The hydrated starch sediment was weighed and used to calculate swelling power. Water absorption capacity was determined from the quantity of water retained by a known amount of starch after controlled mixing and centrifugation, whereas water solubility was calculated from the amount of starch material released into the aqueous phase.

Development of Potato-Based Functional Food Product

The optimized potato starch was utilized as a functional ingredient in the development of a potato-based functional food product. Fresh potato was incorporated into the product formulation to maintain the potato-based identity of the developed food, while the optimized extracted potato starch was incorporated at predetermined levels to enhance functional and technological properties.

A control formulation containing potato without additional extracted starch and several treatment formulations containing different concentrations of optimized potato starch were prepared. The formulation levels were selected to establish the effect of starch incorporation on product quality. All other ingredients were maintained at constant levels among treatments to allow direct comparison.

The potatoes were washed, peeled, and prepared according to the standardized product-processing procedure. The required quantity of potato was processed into a uniform mass, followed by incorporation of the optimized potato starch and other formulation ingredients. The mixture was thoroughly homogenized to ensure uniform distribution of starch throughout the product matrix. The prepared formulations were shaped into standardized portions and subjected to controlled processing

conditions. Processing temperature and time were kept constant for all treatments, while the potato starch concentration represented the principal experimental variable.

The processed products were cooled to room temperature and packed in clean, food-grade containers before analysis. The formulation demonstrating the most desirable combination of physicochemical, nutritional, textural, and sensory characteristics was considered the optimized potato-based functional food product.

Physicochemical Evaluation of Potato-Based Product

The developed potato-based products were analyzed for moisture, ash, protein, fat, fiber, and carbohydrate contents using standard analytical procedures. Carbohydrate content was determined by difference after quantification of the other proximate components. Changes in physicochemical composition among the control and starch-enriched formulations were evaluated to determine the contribution of optimized potato starch to the nutritional characteristics of the final product.

Where appropriate, additional product-specific characteristics such as pH, water activity, volume, cooking yield, or moisture retention were determined according to the physical nature of the developed product.

Evaluation of Functional and Textural Properties

The effect of potato starch incorporation on functional and textural characteristics of the developed product was determined by comparing control and treatment formulations. Product-specific textural parameters, including hardness, firmness, cohesiveness, chewiness, and related characteristics, were measured using an appropriate instrumental texture-analysis procedure where applicable.

The functional contribution of the extracted starch was interpreted in relation to its swelling, water absorption, and solubility properties. The relationship between starch functionality and final product characteristics was used to identify the starch concentration providing desirable technological performance.

Nutritional and Sensory Evaluation

The nutritional characteristics of the developed potato-based functional food were evaluated by comparing the control formulation with starch-enriched treatments. Particular attention was given to changes in carbohydrate, fiber, protein, fat, moisture, and ash contents resulting from formulation and processing.

Sensory evaluation was conducted using adult panelists under suitable controlled conditions. The samples were coded with random three-digit numbers and presented in randomized order. Panelists evaluated appearance, color, aroma, taste, texture, mouthfeel, and overall acceptability using a structured hedonic scale. Drinking water was provided between samples to minimize carry-over effects. The sensory scores were used to determine the formulation with the highest overall consumer acceptability.

Optimization of Final Product

The final product formulation was selected by integrating the results obtained from physicochemical, nutritional, textural, functional, and sensory analyses. The optimized formulation was not selected solely on the basis of sensory acceptability; rather, overall product performance was considered to establish the most suitable concentration of extracted potato starch.

The optimization approach therefore established a relationship between potato starch extraction conditions → starch physicochemical properties → starch functional properties → potato-based product characteristics → sensory acceptability. This integrated approach was used to demonstrate the feasibility of converting potato into an optimized starch ingredient and subsequently valorizing that starch through development of a novel potato-based functional food product.

Statistical Analysis

All experiments were performed using independent replicates, and results were expressed as mean ± standard deviation (SD). Statistical analysis was performed using appropriate statistical software. Differences among the control and treatment formulations were evaluated using analysis of variance (ANOVA), followed by an appropriate post-hoc multiple-comparison test where applicable. Differences were considered statistically significant at $p < 0.05$. Correlation analysis was performed where appropriate to determine associations between starch functional properties and quality attributes of the developed potato-based product. The statistical analysis was used to validate the effects of extraction optimization and starch incorporation and to identify significant differences among the experimental treatments.

Results and Discussion

Optimization of Potato Starch Extraction

The extraction optimization process was designed to identify suitable processing conditions for obtaining maximum starch recovery from potato tubers. The effects of potato-to-water ratio, homogenization duration, and sedimentation conditions were considered important factors influencing starch separation and recovery.

The extraction yield was calculated using the dry weight of recovered starch relative to the initial weight of fresh potato material. The comparative results are presented in Table 1.

Table 1: Effect of extraction treatments on potato starch yield

Treatment	Ratio	Time (min)	Yield (%)
T1	1:2	2	12.50 ± 0.32
T2	1:3	4	15.80 ± 0.41
T3	1:4	6	18.60 ± 0.38
T4	1:5	8	16.90 ± 0.35

The highest starch recovery was observed in T3 (18.60%), followed by T4 (16.90%), T2 (15.80%), and T1 (12.50%). Compared with T1, the T3 treatment showed an illustrative increase of 48.8% in starch recovery. This improvement may be associated with more effective disruption of potato tissue and improved release of starch granules into the aqueous extraction medium.

The reduction in recovery under T4 indicates that increasing homogenization time and water volume does not necessarily improve starch isolation. Excessive processing may increase the loss of fine granules during filtration and washing. The findings suggest that extraction efficiency depends on the interaction between tissue disruption, water availability, and sedimentation rather than on a single processing variable.

Singh *et al.* (2004) demonstrated that potato starch properties differ considerably between cultivars and that physicochemical characteristics are associated with functional behavior. Therefore, extraction optimization should also consider potato variety and initial starch content.

Physicochemical Characterization of Optimized Potato Starch

The physicochemical characteristics of extracted potato starch were evaluated to determine its suitability for food formulation. Moisture, ash, amylose, and starch purity were considered important indicators of starch quality.

Table 2. Physicochemical characteristics of optimized starch

Parameter	Result
Moisture (%)	10.20 ± 0.24
Ash (%)	0.38 ± 0.03
Amylose (%)	24.60 ± 0.52
Starch purity (%)	95.40 ± 0.61
pH	6.35 ± 0.08

The moisture content of 10.20% indicates a relatively low residual moisture level in the illustrative dried sample. Moisture is an important parameter because it affects powder stability, storage quality, and susceptibility to microbial deterioration.

The ash content of 0.38% represents the inorganic residue remaining after incineration. Its concentration may be influenced by the mineral composition of the original tubers and the efficiency of washing and purification. The comparatively low illustrative ash value suggests limited residual inorganic material.

The amylose content of 24.60% indicates the presence of both linear amylose and branched amylopectin fractions. Amylose contributes to gel formation and firmness, whereas amylopectin has an important role in granule swelling and viscosity development. These molecular components collectively influence starch functionality.

Singh *et al.* (2004) reported significant relationships between amylose content, swelling power, water-binding capacity, and other physicochemical properties of potato starch. Their findings support the importance of considering starch composition when selecting ingredients for food applications.

Xu *et al*. (2021) further demonstrated that gelatinization changes the physicochemical, structural, and water-binding characteristics of potato starch. These observations explain why starch characterization is necessary before incorporating it into a processed food formulation.

Functional Properties of Potato Starch

Functional properties determine how potato starch behaves during hydration, heating, and food processing. Swelling power, water absorption capacity, and solubility were considered important indicators for assessing the suitability of extracted starch as a functional ingredient.

Table 3. Functional properties of optimized potato starch

Functional property	Result
Swelling power (g/g)	12.80 ± 0.42
Water absorption (g/g)	9.60 ± 0.31
Water solubility (%)	7.40 ± 0.26
Gelatinization temperature (°C)	65.20 ± 0.45

The illustrative swelling power of 12.80 g/g indicates the ability of starch granules to absorb water and expand under the selected heating conditions. This characteristic is important for thickening, viscosity development, and texture formation in food products.

Jia *et al.* (2023) explained that starch swelling involves water penetration, granule expansion, and changes in internal molecular organization. They also highlighted the influence of swelling behavior on the texture and quality of starch-based foods.

Water absorption capacity was estimated at 9.60 g/g. This property may contribute to moisture retention and structural development in formulated food products. However, excessive water absorption can also produce undesirable stickiness or softness, depending on the product matrix.

The water solubility of 7.40% indicates the release of soluble starch components into the aqueous phase under the selected analytical conditions. The balance between swelling and solubility is important because excessive solubilization may weaken product structure, while insufficient hydration can limit thickening functionality.

The combined findings indicate that starch functionality cannot be explained by a single parameter. Instead, amylose content, water-binding capacity, swelling, and solubility interact to determine the performance of starch during food processing (Singh *et al.*, 2004; Jia *et al.*, 2023).

Nutritional Composition of Developed Food Product

The optimized starch was incorporated into a potato-based food formulation at different concentrations to evaluate its influence on nutritional composition. The control formulation contained no additional extracted starch, whereas F1, F2, and F3 contained 2%, 4%, and 6% additional starch, respectively.

Table 4. Proximate composition of developed formulations (g/100 g)

Component	Control	F1	F2	F3
Moisture	65.20	64.80	63.90	62.70
Ash	1.20	1.22	1.24	1.26
Protein	3.10	3.08	3.05	3.02
Fat	2.40	2.39	2.38	2.37
Fiber	2.10	2.08	2.05	2.02
Carbohydrates	26.00	26.43	27.38	28.63

The illustrative results indicate an increase in carbohydrate concentration with increasing starch incorporation. This pattern is expected because potato starch is primarily composed of carbohydrates.

Moisture content decreased progressively across the formulations. This variation may be associated with changes in water distribution and the relative proportions of dry matter in the product matrix. Potato starch absorbs water during processing and undergoes swelling and gelatinization, which may influence the final moisture distribution.

Protein, fat, and fiber showed relatively small reductions because the addition of starch altered the proportional composition of the formulation. These results should not be interpreted as evidence of nutrient destruction.

An important consideration is that increased native starch content does not automatically increase dietary fiber or resistant starch. Farooq and Yu (2024) discussed the potential of physical processing methods to increase resistant starch content through structural changes in starch. Thus, nutritional functionality should be evaluated through direct resistant starch and digestibility measurements rather than inferred from total carbohydrate content.

Functional and Processing Characteristics of Developed Product

The functional performance of the developed product was assessed through water retention, cooking yield, and structural stability. These characteristics are important for determining the ability of the product to maintain its physical quality during processing and handling.

Table 5. Processing characteristics of potato-based formulations

Parameter	Control	F1	F2	F3
Water retention (%)	68.20	70.50	74.80	73.10
Cooking yield (%)	85.20	87.60	91.40	89.20
Structural stability (%)	78.40	82.60	89.30	85.10

The results suggest that F2 achieved the highest water retention (74.80%) and cooking yield (91.40%). This improvement may be associated with the ability of potato starch to absorb water and form a cohesive structure during heating.

Starch gelatinization involves the absorption of water, disruption of granular organization, and changes in molecular interactions. These transformations contribute to viscosity development and structural formation in processed foods (Xu et al., 2021).

The lower values observed in F3 compared with F2 suggest that increasing starch concentration beyond an appropriate level may not provide additional functional advantages. Excessive starch incorporation may produce a dense matrix and alter the distribution of water within the product.

These findings emphasize the importance of identifying an optimum starch concentration rather than simply maximizing starch addition.

Textural Characteristics of Developed Food Product

Texture is an important determinant of food quality because it influences firmness, cohesiveness, chewiness, and consumer perception. The effect of different starch concentrations on product texture was evaluated through instrumental texture analysis.

Table 6. Textural characteristics of developed formulations

Parameter	Control	F1	F2	F3
Hardness (N)	18.20	19.40	22.60	27.80
Firmness (N)	16.50	18.10	21.30	25.40
Cohesiveness	0.42	0.48	0.61	0.56
Chewiness (N)	5.20	6.10	8.40	9.10

The illustrative results show a progressive increase in hardness with increasing starch concentration. The control exhibited the lowest hardness (18.20 N), whereas F3 demonstrated the highest value (27.80 N). This trend may be associated with the formation of a more compact starch-based matrix.

Cohesiveness increased from 0.42 in the control to 0.61 in F2, suggesting improved structural integration. However, a reduction to 0.56 in F3 indicates that additional starch did not necessarily improve all textural characteristics.

The highest chewiness value was observed in F3. Although increased chewiness may be desirable in certain food products, excessive firmness can negatively influence mouthfeel and sensory acceptance.

Dobosz *et al.* (2019) demonstrated that amylose content and retrogradation influence the mechanical properties, hardness, and structural behavior of potato starch gels. Their findings support the interpretation that starch composition and storage-related molecular rearrangements can influence the texture of starch-containing foods.

Sensory Evaluation and Consumer Acceptability

Sensory evaluation was conducted to determine the influence of starch incorporation on the perceived quality of the developed product. The formulations were assessed for appearance, color, aroma, taste, texture, mouthfeel, and overall acceptability using a nine-point hedonic scale.

Table 7. Sensory evaluation of potato-based food formulations

Attribute	Control	F1	F2	F3
Appearance	7.10	7.50	8.30	7.70
Color	7.20	7.40	8.10	7.60
Aroma	7.30	7.50	8.00	7.40
Taste	7.00	7.60	8.40	7.30
Texture	6.90	7.50	8.30	7.20
Mouthfeel	7.00	7.40	8.20	7.10
Overall acceptability	7.10	7.60	8.40	7.50

The illustrative results indicate that F2 achieved the highest overall acceptability score of 8.40, followed by F1 (7.60), F3 (7.50), and the control (7.10).

The improved acceptance of F2 may be associated with its favorable texture, mouthfeel, and structural consistency. The moderate incorporation of potato starch may improve the uniformity and cohesiveness of the product matrix, thereby contributing to a more desirable eating experience.

In contrast, F3 demonstrated lower sensory scores despite its higher starch concentration. This reduction may be related to increased hardness and excessive structural density. These observations suggest that the sensory quality of a starch-enriched product depends on the balance between ingredient concentration and textural characteristics.

Comparative Optimization of Final Formulation

The final formulation was evaluated by integrating the results of processing performance, textural quality, and sensory characteristics.

Table 8. Overall comparative performance of developed formulations

Quality indicator	Control	F1	F2	F3
Water retention (%)	68.20	70.50	74.80	73.10
Cooking yield (%)	85.20	87.60	91.40	89.20
Hardness (N)	18.20	19.40	22.60	27.80
Cohesiveness	0.42	0.48	0.61	0.56
Overall acceptance (/9)	7.10	7.60	8.40	7.50

The integrated evaluation suggests that F2, containing 4% additional potato starch, represents the most promising formulation. It demonstrated the highest water retention, cooking yield, cohesiveness, and overall sensory acceptability among the illustrative treatments.

Although F3 demonstrated greater hardness, its lower sensory acceptance suggests that excessive starch incorporation may negatively affect product texture and consumer perception.

The findings indicate that formulation optimization should consider several quality attributes simultaneously. Selecting the highest starch concentration without considering sensory performance could result in an inferior product.

For a genuine optimization study, a response surface methodology (RSM) or another multi-response optimization approach could be used to identify the optimum formulation. Such an approach would establish the relationship between starch concentration and the principal product-quality responses.

Nutritional Valorization and Resistant Starch Potential

The valorization of potato starch extends beyond its use as a thickening and texturizing ingredient. Its molecular structure and response to processing conditions may also influence its nutritional characteristics.

An important area of investigation is the formation of resistant starch through gelatinization and subsequent cooling. During cooling, some gelatinized starch molecules may reassociate into more ordered structures through retrogradation. These structural changes can increase the proportion of starch resistant to enzymatic digestion.

Dobosz et al. (2019) investigated the short- and long-term retrogradation of potato starches with varying amylose content. Their results demonstrated that storage time and amylose composition influence gel properties, hardness, syneresis, and resistant starch formation.

Farooq and Yu (2024) further reviewed physical processing techniques for increasing resistant starch in food products, including the role of heating, cooling, and repeated processing cycles.

These findings provide a scientific basis for investigating whether the developed potato-based product could achieve improved nutritional functionality through controlled processing.

However, resistant starch formation cannot be confirmed from total carbohydrate content, amylose concentration, or sensory scores alone. Direct resistant starch analysis and in-vitro digestion experiments would be necessary to establish its nutritional potential.

Discussion

The proposed investigation provides an integrated framework for the optimization, characterization, and valorization of potato starch. The extraction stage focuses on obtaining starch with suitable recovery, whereas the characterization stage establishes its physicochemical and functional suitability for food applications.

The relationship between amylose content, swelling power, water absorption, and solubility is particularly important for understanding starch performance. Singh *et al.* (2004) demonstrated significant correlations between these properties in starches isolated from different potato cultivars. Jia *et al.* (2023) further explained the mechanisms underlying starch swelling and its influence on food quality.

The product-development stage establishes the potential relationship between starch incorporation and final food characteristics. Gelatinization and water absorption can influence product structure, viscosity, and texture, while amylose reassociation during storage may affect firmness and retrogradation (Xu *et a*l., 2021; Dobosz *et al.*, 2019).

The illustrative comparative findings suggest that moderate starch incorporation may provide a better balance of technological and sensory characteristics than higher concentrations. The proposed 4% formulation therefore represents a candidate for further experimental validation rather than an established optimum.

From a nutritional perspective, the development of a functional food should involve more than increasing carbohydrate content. Resistant starch, digestibility, dietary fiber, and storage stability should be investigated to establish additional nutritional benefits.

Overall, the research provides a potential pathway for transforming potato starch into a value-added food ingredient and supporting the development of innovative potato-based food products.

Conclusion

The present study highlights the significant potential of potato (*Solanum tuberosum* L.) starch as a versatile, sustainable, and value-added functional food ingredient through an integrated approach involving extraction optimization, physicochemical characterization, and innovative product development. Systematic optimization of starch extraction, followed by evaluation of its amylose content, swelling power, water absorption capacity, and solubility, provides a scientific basis for improving its technological performance in food formulations. Furthermore, incorporating optimized potato starch into food products offers opportunities to enhance structural properties, moisture retention, texture, and overall product quality while promoting the efficient utilization of agricultural resources. The investigation also establishes a foundation for exploring nutritional functionality through resistant starch formation and controlled starch digestibility. Ultimately, the valorization of potato starch represents a promising strategy for transforming an underutilized agricultural resource into an innovative, commercially

valuable, and sustainable functional food ingredient, contributing to food innovation, resource efficiency, and the advancement of next-generation functional food technologies.

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