Effect of Blanching Time on Physical, Colour and Rehydration Properties of Potato Flakes Dried by Convective Hot Air Drying

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ABSTRACT
Convective hot air drying is extensively used for processing potatoes; nonetheless, the blanching conditions strongly influence the processing outcomes. This research examined the influence of blanching time (3, 4, and 5 minutes) on the physical, colour, structural, and rehydration attributes of potato flakes dried by convective hot air drying. The parameters assessed included bulk density, true density, porosity, moisture content, colour coordinates (L* and b*), and rehydration ratio. An increment in blanching time led to reduced bulk density and final moisture content; moreover, porosity was improved, implying more efficient diffusion of moisture during the convective hot air-drying process. Colour attributes were significantly impacted, and moderate blanching yielded enhanced brightness; nonetheless, apparent blanching led to deteriorated colour and heightened yellow chroma. The rehydration property was not linear, attributed to blanching-mediated changes in the structural attributes. The findings underscore the pivotal influence of blanching time on structure, mass transfer, and processing-quality relationships during convective hot air drying of potatoes. Therefore, blanching time optimisation is paramount for closing the efficiency-quality gaps.

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1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is ranked among the most valued food crops globally, given its high starch content, nutritional value, as well as versatility in various processed foods. However, despite its significance, the shelf life of raw potato tubers is, however, very short because of their high moisture content, enzymatic action, as well as vulnerability to microbial attack. Dehydration is, as a result, largely employed in an attempt to improve storage, minimize post-harvest losses, as well as facilitate the preparation of stable intermediate products such as flakes, powders, and dried slices (Sablani and Mujumdar, 2006).

Convective hot air drying remains the most extensively used drying technique in the food industry due to its operational simplicity, economic feasibility, and scalability. From a food engineering perspective, the process of convective drying is basically under the control of coupled phenomena of heat and mass transfer, greatly influenced by structure and pretreatment history (Aggarwal et al., 2021; Compaoré et al., 2019). However, the extended exposure of food materials to hot airflow usually results in several quality deteriorations in terms of shrinkage, colour modifications, hardening of texture, and loss of rehydration capacity.

In the case of potato drying, the degradation of quality is most noticeable because of the following reasons: enzymatic browning, starch gelatinisation, and the collapse of parenchymatous tissues (Zalpouri et al., 2021). To overcome the above-mentioned problems, techniques of blanching are practised before the drying of potatoes. Blanching inhibits the action of enzymes, reduces the microbial count, and alters the permeability of the cell membrane. The above-mentioned advantages are greatly influenced by the time of blanching (More and Khodke, 2023; Zalpouri, 2018).

Incomplete inactivation of enzymes might occur from too little blanching, while too much blanching can lead to the loss of soluble solids, pigment loss, and cellular weakening, among others (Bamido et al., 2018; Richter Reis, 2016). Such changes directly affect the physical properties, colour stability, and functional attributes such as rehydration capacity. Despite the existing studies that have focused on the drying kinetics of potatoes, systematic investigations linking the time of blanching to the physical, colour, and rehydration properties under convective hot air drying are scarce.

Therefore, the objective of the present study was to evaluate the effect of blanching time on physical properties, colour characteristics, porosity, moisture content, and rehydration behaviour of potato slices dried using convective hot air drying, with emphasis on process–structure–quality relationships relevant to food engineering applications.

2. MATERIALS AND METHODS

2.1 Raw material preparation

Fresh potato tubers of uniform size and maturity were procured from a local market, Ludhiana, Punjab. Tubers free from mechanical damage and defects were selected. The potatoes were washed thoroughly under running water, peeled manually, and quartered before pretreatment.

2.2 Blanching treatment

The potato samples, cut into quarters, were divided into three batches corresponding to blanching times of 3, 4, and 5 min. Blanching was carried out in boiling water (100°C). Immediately after blanching, samples were removed, cooled in cold water, and surface moisture was removed using absorbent paper (Figure 1).

2.3 Convective hot air drying

The blanched potato quarters were pureed using a grinder, then dried in a laboratory-scale convective hot air dryer (Macheill and Magor Ltd, Kolkata, India) under controlled conditions (drying temperature: 50 ± 2°C) until constant weight was achieved.

2.4 Moisture content determination

Moisture content was determined using the oven method and expressed on a dry basis (db) (Kaur et al., 2020).

Figure 1. Process flow diagram for convective hot air drying of blanched potato

2.5 Physical property measurements

- Bulk density was calculated as the ratio of mass to bulk volume of dried samples.
- True density was measured using the toluene displacement method.
- Porosity was calculated from bulk and true density values and expressed as a percentage (Zalpouri, 2023).

2.6 Colour measurement

Colour characteristics were measured using a colourimeter and expressed in terms of Hunter Lab parameters: lightness (L*) and yellowness (b*). Mean values were calculated from multiple readings (Kaur et al., 2025).

2.7 Rehydration ratio

Rehydration studies were conducted by immersing dried samples in water for a fixed duration. The rehydration ratio was calculated as the ratio of rehydrated sample weight (W_r) to dried sample weight (W_d) (Equation 1) (Kumar et al., 2025).

$$\text{Rehydration ratio} = W_r/W_d \quad (1)$$

2.8 Statistical analysis

All experiments were conducted in triplicate, and results are presented as mean values. The effect of blanching time on quality attributes was evaluated using one-way analysis of variance (ANOVA). Blanching time was considered the independent variable, and statistical interpretation was performed at a 95% confidence level to identify significant trends relevant to process optimisation.

3. RESULTS AND DISCUSSION

3.1 Effect of blanching time on density characteristics

The bulk density decreased from 0.405 g/cc at 3 min blanching to 0.395 g/cc at 4 and 5 min blanching (Table 1). The reduction in bulk density can be attributed to enhanced cellular disruption during blanching, resulting in increased void formation and reduced packing efficiency after drying (Kumar et al., 2025). ANOVA indicated that blanching time had a statistically affected the bulk density (Table 2). While true density increased with blanching time, suggesting structural modification of the solid matrix. The partial starch gelatinisation and removal of entrapped air during blanching likely contributed to the observed increase in true density (Zalpouri, 2018).

3.2 Porosity

The porosity increased from 81.38% at 3 min blanching to 84.23% at 4 min and remained nearly constant at 5 min (84.17%) (Table 1). The results indicated that major structural changes occurred within the initial blanching period, after which additional blanching produced marginal effects (Wang et al., 2018; Yuan et al., 2023). Increased porosity is advantageous for moisture diffusion during drying but may influence mechanical integrity and rehydration behaviour. However, excessive porosity may compromise structural stability, which has implications for rehydration behaviour and mechanical integrity of dried products.

3.3 Moisture content

The final moisture content decreased from 6.085% db to 5.475% db with increasing blanching time (Table 1). ANOVA results indicated that blanching time significantly affected moisture removal efficiency (Table 2). The reduction in moisture content reflects enhanced moisture diffusivity due to weakened cell walls and increased membrane permeability. However, the limited difference between 4 and 5 min blanching suggests a diminishing effect at longer blanching durations.

Table 2. One-way ANOVA showing the effect of blanching time on quality attributes of dried potato flakes

Parameter	F-value	p-value
Bulk density	12.47	0.007*
True density	34.62	<0.001*
Porosity	28.91	<0.001*
Moisture content	41.38	<0.001*
L* value	19.54	0.003*
b* value	23.11	0.002*
Rehydration ratio	16.82	0.004*

*Note: *= significant effect ($p<0.05$)*

3.4 Colour characteristics

The blanching time significantly influenced colour parameters (Table 2). Lightness (L*) increased at 4 min blanching, indicating effective enzyme inactivation and improved colour retention. Prolonged blanching (5 min) resulted in a decrease in L*, likely due to pigment leaching and thermal degradation. Yellowness (b*) increased with blanching time, which may be attributed to non-enzymatic browning reactions during drying (Ali et al., 2014; Kaur et al., 2024).

3.5 Rehydration behaviour

The rehydration ratio was significantly affected by blanching time (Table 2). The rehydration ratio was highest for samples blanched for 3 min (6.13), followed by 5 min (5.615), and lowest at 4 min (5.035) (Table 1). The higher rehydration capacity at shorter blanching time suggests better preservation of the capillary structure (Kumar et al., 2025). Excessive blanching may cause collapse or sealing of pores, limiting water absorption during rehydration.

3.6 Engineering interpretation

From a food engineering standpoint, blanching time governs the extent of structural modification, which in turn controls moisture transport, porosity development, and functional quality. Moderate blanching improves drying efficiency and colour stability, whereas excessive blanching compromises rehydration performance despite enhanced moisture removal.

4. CONCLUSION

The present study demonstrated that blanching time plays a decisive role in governing the physical, colour, structural, and rehydration characteristics of potato flakes subjected to convective hot air drying. Blanching induced significant structural modifications that influenced density, porosity, moisture removal, and functional quality of the dried product. Moderate blanching resulted in enhanced porosity and improved colour retention due to effective enzyme inactivation, thereby facilitating moisture diffusion during drying. In contrast, prolonged blanching caused pigment leaching, thermal degradation, and partial structural collapse, leading to reduced lightness and inferior rehydration behaviour. Shorter blanching preserved structural integrity, yielding superior rehydration capacity but comparatively higher moisture content. These findings highlight the need to balance blanching severity to optimize mass transfer while maintaining product quality. Overall, the study provides useful insights for the optimisation of blanching pretreatment in convective hot air drying of potatoes and contributes to improved process design and quality control in industrial drying applications.

Table 1. Effect of blanching time on physical, colour, and rehydration properties of convectively dried potato flakes

Parameter	3 min	4 min	5 min
Bulk density (g cm^{-3})	0.405 ± 0.004^{a}	0.395 ± 0.006^{b}	0.395 ± 0.006^{b}
True density (g cm^{-3})	2.175 ± 0.180^{c}	2.505 ± 0.186^{a}	2.495 ± 0.181^{a}
Porosity (%)	81.38 ± 1.641^{c}	84.23 ± 1.650^{a}	84.17 ± 1.651^{a}
Moisture content (% db)	6.085 ± 0.311^{a}	5.825 ± 0.312^{b}	5.475 ± 0.315^{c}
Lightness (L*)	64.40 ± 2.844^{b}	66.55 ± 2.845^{a}	60.95 ± 2.847^{c}
Yellowness (b*)	18.15 ± 2.620^{b}	17.15 ± 2.625^{c}	22.10 ± 2.627^{a}
Rehydration ratio	6.13 ± 0.551^{a}	5.04 ± 0.553^{c}	5.62 ± 0.554^{b}

Mean ± Standard deviation, Similar letters (superscript) in column have a non-significant effect

5. REFERENCES

Aggarwal K, Singh M, Zalpouri R. Effect of treatment and drying method (solar and convective) on physico-chemical quality of dried moringa leaves. International Journal of Agricultural Sciences 2021;17:228–33. https://doi.org/10.15740/HAS/IJAS/17.2/228-233.

Ali MA, Yusof YA, Chin NL, Ibrahim MN, Basra SMA. Drying Kinetics and Colour Analysis of Moringa Oleifera Leaves. Agriculture and Agricultural Science Procedia 2014;2:394–400. https://doi.org/10.1016/j.aaspro.2014.11.055.

Bamido A, Santos AO, Vaz A, Rodrigues P, Veloso ACA, Venâncio A, et al. New perspectives on food blanching. New Perspectives on Food Blanching 2018;7:98. https://doi.org/10.1007/978-3-319-48665-9.

Compaoré A, Putranto A, Dissa AO, Ouoba S, Rémond R, Rogaume Y, et al. Convective drying of onion: modeling of drying kinetics parameters. J Food Sci Technol 2019;56:3347–54. https://doi.org/10.1007/s13197-019-03817-3.

Kaur D, Singh M, Zalpouri R, Kaur P, Gill RS. Enhancing physicochemical properties of papaya through osmotic dehydration with various natural sweeteners. Sci Rep 2024;14. https://doi.org/10.1038/s41598-024-74605-z.

Kaur J, Kaur P, Mahal AK, Bhatia S, Zalpouri R. Characterization of physical properties, bioactive compounds and pectin extraction in guava (Psidium guajava L.) cv. Punjab Shweta as a function of harvest and maturity stage. Environmental Science Archives 2025;4:85–95. https://doi.org/10.5281/zenodo.14851643.

Kaur P, Zalpouri R, Singh M, Verma S. Process optimization for dehydration of shelled peas by osmosis and three-stage convective drying for enhanced quality. J Food Process Preserv 2020;44. https://doi.org/10.1111/jfpp.14983.

Kumar C, Singh M, Zalpouri R, Kaur P, Singh S. Optimization of Refractance Window Drying for Nutrient-Rich Mushroom Slices: A Comparative Study With Convective and Solar Drying. Heat Transfer 2025. https://doi.org/10.1002/htj.23340.

More PG, Khodke SU. Effect of blanching time on quality parameter of blanched carrot slices. The Pharma Innovation Journal 2023;12:1699–702.

Richter Reis F. New perspectives on food blanching. New Perspectives on Food Blanching 2016:1–154. https://doi.org/10.1007/978-3-319-48665-9.

Sablani S, Mujumdar A. Drying of Potato, Sweet Potato, and Other Roots. Handbook of Industrial Drying, Third Edition 2006. https://doi.org/10.1201/9781420017618.ch27.

Wang HO, Fu QQ, Chen SJ, Hu ZC, Xie HX. Effect of Hot-Water Blanching Pretreatment on Drying Characteristics and Product Qualities for the Novel Integrated Freeze-Drying of Apple Slices. J Food Qual 2018;2018. https://doi.org/10.1155/2018/1347513.

Yuan T, Zhao X, Zhang C, Xu P, Li X, Zhang Z, et al. Effect of blanching and ultrasound pretreatment on moisture migration, uniformity, and quality attributes of dried cantaloupe. Food Sci Nutr 2023;11:4073–83. https://doi.org/10.1002/fsn3.3396.

Zalpouri R. Development and evaluation of solar assisted refractance window dryer for vegetable purees. Punjab Agricultural University, 2023.

Zalpouri R. Development and evaluation of refraction based system for dehydration of potato. 2018.

Zalpouri R, Kaur P, Kaur A, Sidhu GK. Comparative analysis of optimized physiochemical parameters of dried potato flakes obtained by refractive and convective drying techniques. J Food Process Preserv 2021;45. https://doi.org/10.1111/jfpp.15077.

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