International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2025; 9(2): 559-564
www.biochemjournal.com
Received: 18-11-2024
Accepted: 23-12-2024

S Saranya
Department of Processing & Food Engineering, Kelappaji College of Agricultural Engineering and Food Technology, Kerala Agricultural University, Tavanur, Kerala, India

S Abdullah
Agribusiness Incubator, Department of Agricultural Engineering, College of Agriculture, Kerala Agricultural University, Thrissur, Kerala, India

Kundukulanagara Pulissery Sudheer
Department of Agricultural Engineering, College of Agriculture, Kerala Agricultural University, Thrissur, Kerala, India

Corresponding Author:
S Saranya
Department of Processing & Food Engineering, Kelappaji College of Agricultural Engineering and Food Technology, Kerala Agricultural University, Tavanur, Kerala, India

Optimisation of retort pouch processing parameters for preserving ripe jackfruit pulp

S Saranya, S Abdullah and Kundukulanagara Pulissery Sudheer

DOI: https://doi.org/10.33545/26174693.2025.v9.i2h.3833

Abstract
Jackfruit (*Artocarpus heterophyllus* Lam.) is a tropical fruit valued for its rich nutritional and bioactive profile, including ascorbic acid (AA), phenolic compounds, flavonoids, and antioxidant activity. However, its high perishability necessitates effective preservation methods, such as retort processing, to ensure microbial safety and extended shelf life. This study investigates the impact of retort processing on the physicochemical and bioactive properties of ripe jackfruit pulp, focusing on AA, total phenolic content (TPC), total flavonoid content (TFC), DPPH antioxidant activity, total sugar, and microbial reduction. RJP was subjected to retort processing at different temperature-time combinations (105-120 °C for 5-15 minutes). Process optimization identified 106 °C for 5 minutes as the ideal retort processing condition, yielding a high desirability value of 0.956. Under these conditions, AA (11.03±0.38 mg/100 g), TPC (68.53±3.14 mg GAE/100 g), and total sugar (20.07±0.69%) were maximized, while microbial load remained within safe limits (<1 log CFU/g). DPPH antioxidant activity slightly decreased from 82.83±3.80% to 80.48±2.90%, with temperature identified as the dominant factor influencing quality parameters (p<0.0001). These findings highlight the importance of optimizing retort processing parameters to balance microbial safety, nutritional integrity, and extended shelf life. The study provides valuable insights for the food processing industry in developing high-quality, shelf-stable jackfruit-based product.

Keywords: Antioxidant activity, ascorbic acid, phenolic content, retort processing, ripe jackfruit pulp

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) is a highly nutritious tropical fruit widely consumed for its rich carbohydrate content, dietary fiber, vitamins, and bioactive compounds (Swami *et al*., 2012) [14]. It is an excellent source of ascorbic acid (AA), phenolic compounds, flavonoids, and antioxidants, which contribute to its health-promoting properties, including antioxidant, anti-inflammatory, and antimicrobial effects (Baliga *et al*., 2011) [2]. However, the high moisture content of ripe jackfruit pulp makes it highly perishable, necessitating effective preservation techniques to extend its shelf life while maintaining its nutritional and sensory quality.

Retort processing is a widely used thermal processing method that ensures food products' microbial safety and shelf stability. However, the high temperatures and prolonged processing times associated with retort processing can lead to the degradation of heat-sensitive nutrients, including AA, phenolic compounds, and flavonoids, and may induce undesirable Maillard reactions, colour changes, and texture modifications (Lund and Ray., 2017) [6]. Studies on other fruit and vegetable-based products, such as garlic mashed potatoes (Patel *et al*., 2020) [9] and canned mandarin slices (Perez-Lopez *et al*., 2011) [10], have reported significant losses in vitamin C, phenolic content, and flavonoids due to retort processing. While extensive research exists on the effects of retort processing on various fruit-based products, limited studies have investigated the impact of retort processing on the nutritional and bioactive profile of ripe jackfruit pulp.

The present study aims to evaluate the effect of retort processing on the physicochemical and bioactive properties of ripe jackfruit pulp. Furthermore, response surface methodology was employed to optimize retort processing conditions, ensuring maximum retention of nutritional quality while maintaining microbial safety. The findings from this study will contribute to the development of scientifically validated processing strategies for high-quality, shelf-stable jackfruit-based products suitable for industrial applications.

2. Materials and Methods

2.1 Sample preparation

Fully matured ripe jackfruit (*Artocarpus heterophyllus*), specifically of the Varikka variety with uniform ripeness, was procured from a local orchard. After surface sanitation and thorough cleaning with tap water, the bulbs were separated from the fibrous strands and deseeded before pulping. An industrial mixer (Make: Sarah's Techno, India was used to achieve uniform pulping of the deseeded pulp. The processed pulp was then transferred into retort pouches for thermal processing.

2.2 Experimental design and process optimization

The retort pouch processing parameters for preserving ripe jackfruit pulp were optimized using response surface methodology based on a central composite design. The independent variables selected for optimization included temperature (105-120 °C), processing time (5-15 min.). The experimental design consisted of a set of factorial and axial points, along with central points to evaluate the curvature effects.

2.3 Thermal Processing

Ripe jackfruit pulp was processed using a steam-air retort (I-Tech Equipment, India). Retort pouches (250 g capacity) were filled with 150 g of pulp, and excess air was removed using high-pressure steam before sealing with a pneumatic sealer (Sevana, Model: QS300PNI). The sealed pouches were loaded into the retort and thermally processed under precisely controlled conditions as per the experimental design. Post-processing, rapid cooling was achieved using a water spray system and compressed air to stabilize pressure and maintain product integrity.

2.4 Physicochemical and Nutritional Analysis

The physicochemical properties, including AA, total phenolic content (TPC), total flavonoid content (TFC), DPPH radical scavenging activity, total sugar, and microbial analysis, were assessed to evaluate thermal processing effects on ripe jackfruit. The quantification of AA was performed via the 2, 6-dichlorophenolindophenol titration assay, leveraging the ability of AA to reduce the dye to a colourless leuco-form. This method followed the protocol described by AOAC standard method (AOAC, 1990) [1]. Total sugar in processed ripe jackfruit pulp was measured using Ranganna (1986) [11]. TPC was estimated with Folin-Ciocalteu reagent (Kaushik *et al*., 2014), while TFC was determined via a colorimetric assay (Saranya *et al*., 2024) [13] for retort pouch-processed samples. DPPH radical scavenging activity, reflecting antioxidant potential, was spectrophotometrically analyzed per Marinova and Batchvarov. (2011) [7]. Furthermore, microbial quality assessment of thermally processed ripe jackfruit was conducted according to the methodology established by Saranya *et al*. (2024) [13], ensuring compliance with food safety and quality standards.

2.5 Statistical Analysis

The experimental data were analyzed using Design-Expert software (Version 7; Stat-Ease Inc., Minneapolis, USA). Analysis of variance (ANOVA) was performed to determine the statistical significance of the model terms, and p-values were used to assess the influence of the independent variables and their interactions. The adequacy of the model was evaluated based on regression coefficients, lack-of-fit tests, and response surface plots. Optimization was carried out using the desirability function to identify the optimal processing conditions for preserving the quality attributes of jackfruit pulp.

3. Results and Discussion

3.1 Effect of retort processing on AA content in ripe jackfruit

The AA content in retorted ripe jackfruit pulp ranged from 7.62±0.28 mg/100 g to 11.33±0.40 mg/100 g, whereas the fresh pulp contained 12.45±0.57 mg/100 g prior to retort processing. The response surface plot (Fig.1) illustrates the effect of temperature and process time on the AA content of processed ripe jackfruit pulp. The AA content varies significantly with changes in these processing parameters, highlighting the thermal sensitivity of this vital nutrient.

At lower temperatures, approximately 105 °C, and shorter processing times around 5 minutes, the highest AA content is observed, reaching nearly 11.33±0.40 mg/100 g. This indicates minimal thermal degradation under mild processing conditions, preserving a higher concentration of AA in the retorted pulp.

Conversely, as the temperature increases to around 120 °C and the process time extends to 15 minutes, the AA content declines significantly, reaching its lowest value of approximately 7.62±0.28 mg/100 g. This trend suggests that prolonged exposure to elevated temperatures accelerates the breakdown of AA, likely due to oxidation and thermal degradation (Mercali *et al*., 2014) [8]. Similar trends have been reported in other food matrices; for instance, Patel *et al*. (2020) [9] documented an 18% reduction in vitamin C content following retort processing of garlic mashed potatoes. The observed variability in AA retention across different batches suggests the influence of retort processing conditions.

Statistical analysis revealed that the models predicting AA degradation were highly significant, with an F-value of 65.03 and p-values < 0.0001, confirming minimal experimental noise. Temperature (T) and process time (t) were identified as critical factors influencing AA retention, with temperature having a more pronounced effect.The quadratic term for temperature (T^2) was also significant, suggesting the existence of an optimal thermal range for minimizing AA degradation. The regression equation for These findings underscore the importance of precise temperature control in optimizing AA retention during retort processing of both jackfruit pulp and bulbs. The regression equation for the suggested quadratic model of AA of ripe jackfruit pulp in terms of the coded equation is given below

$$\text{AA of ripe jackfruit pulp (mg/100 g)} = 10.14-1.21* T-0.52* t-0.24* T * t-0.38* T^2+0.094* t^2 \quad \ldots(1)$$

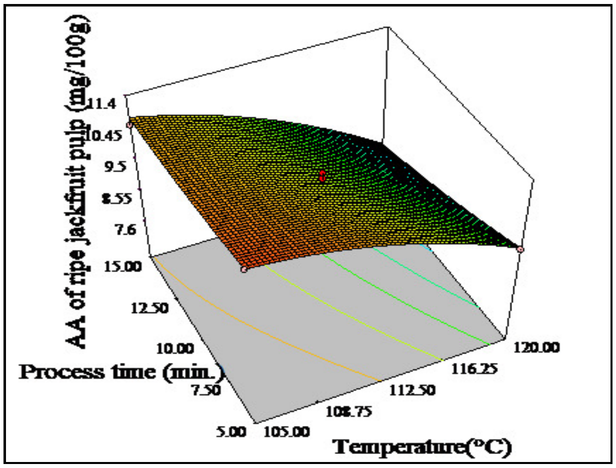

Fig 1: AA content of retort processed ripe jackfruit pulp

3.2 Effect of retort processing on TPC and TFC in ripe jackfruit

The TPC of processed ripe jackfruit pulp varied between 56.49±2.59 mg GAE/g and 64.85±2.83 mg GAE/g (Fig.2), whereas fresh pulp contained 68.53±1.81 mg GAE/g. A notable reduction in phenolic content was observed after retort processing, with the highest decline (17.56%) occurring at 123 °C for 10 minutes. This reduction is likely attributed to the thermal degradation of phenolic compounds during processing. Similar trends have been reported in Chokanan mango juice (Santhirasegaram *et al*., 2013) [12], where heat exposure led to a decrease in total polyphenol content due to the breakdown of these compounds outside a protective matrix (Cilla *et al*., 2012) [4]. These findings underscore the vulnerability of phenolic compounds to high temperatures, highlighting the importance of optimising retort processing conditions to minimize their degradation. Statistical analysis demonstrated that temperature (T) had a highly significant effect on TPC ($p<0.0001$, $R^2 = 0.9734$), while time (t) also influenced phenolic retention significantly ($p<0.05$). The response surface quadratic model exhibited a strong overall fit for pulp with high R^2 values. The regression equation for the suggested quadratic model of TPC of ripe jackfruit pulp in terms of the coded equation is given below

$$\text{TPC (mg GAE/g)} = 63.51 - 3.06 * T - 0.61 * t - 0.17 * T * t - 1.79 * T^2 - 0.33 * t^2 \quad \ldots(2)$$

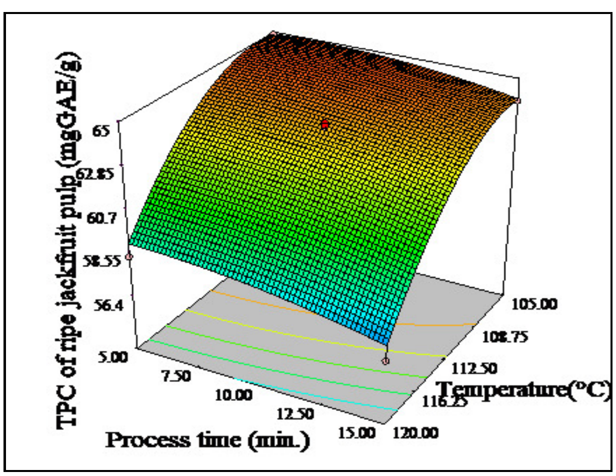

Fig 2: TPC of retorted ripe jackfruit pulp

The TFC in processed pulp varied between 14.7±0.67 mg RE/g and 18.56±0.85 mg RE/g, whereas fresh pulp exhibited a notably higher TFC of 20.33±0.73 mg RE/g. This reduction in flavonoid content suggests that retort processing adversely affects these bioactive compounds, with the most substantial decline observed at 120 °C for 15 minutes (Fig.3). The findings indicate that higher processing temperatures may accelerate flavonoid degradation, which is consistent with similar trends reported in . milk-based fruit drinks (Cilla *et al*., 2012) [4]. These observations further underscore the importance of optimizing retort processing parameters to preserve flavonoids while ensuring product safety and stability. ANOVA results confirmed significant effects ($p<0.0001$) of retort processing conditions (T,t) on flavonoid retention in jackfruit pulp. The regression equation for the suggested quadratic model of TFC of ripe jackfruit pulp in terms of the coded equation is given below

$$\text{TFC (mg RE/g)} = 17.35 - 1.35\ T - 0.60\ t - 0.26\ T\ t - 0.43\ T^2 + 0.018\ t^2 \quad \ldots(3)$$

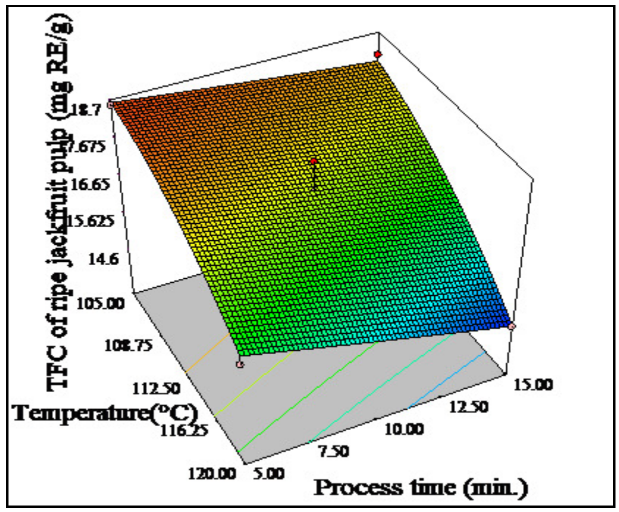

Fig 3: TFC of retorted ripe jackfruit pulp

3.4 Effect of retort processing on DPPH radical scavenging activity in ripe jackfruit

The DPPH radical scavenging activity in processed ripe jackfruit pulp ranged from 82.83±3.80% to 80.48±2.90%, while the fresh pulp exhibited a higher antioxidant activity of 83.29±3.63%. Notably, the most significant reduction in DPPH radical scavenging activity was observed at 120 °C for 15 minutes (Fig.4), suggesting that higher temperatures and prolonged retort processing times may contribute to a more pronounced decline in antioxidant potential. The antioxidant activity of processed ripe jackfruit pulp exhibited a notable dependency on temperature and processing time. The highest recorded DPPH radical scavenging activity value was 82.83% at 105 °C for 5 minutes, whereas the lowest was 80.48% at 120 °C for 15 minutes. This indicates a decline in antioxidant potential as temperature and time increase. At lower temperatures (105 °C-112.5 °C), the DPPH radical scavenging activity values remained relatively stable, suggesting minimal degradation of antioxidant compounds. However, as the processing temperature exceeded 120 °C, a noticeable reduction in DPPH radical scavenging activity was observed. This decline can be attributed to the thermal breakdown of heat-sensitive antioxidant compounds, such as polyphenols and flavonoids. Prolonged exposure further exacerbated this effect, as seen in the lowest DPPH radical scavenging activity value at 120 °C for 15 minutes. Despite this reduction, the retention of antioxidant activity across all conditions remained relatively high, with values above 80%, indicating that high-pressure processing effectively preserves bioactive compounds. The observed decrease in DPPH radical scavenging activity after retort processing indicates a potential loss of antioxidant compounds, which are essential for mitigating oxidative stress and preserving food quality (Vallverdú-Queralt *et al*., 2012) [15]. Statistical analysis confirmed the significance of the model in predicting DPPH radical scavenging activity, with an F-value of 35.33 and p-values < 0.0001, indicating minimal experimental noise. Temperature (T) and time (t) were identified as key influencing factors, with temperature exerting a stronger impact and the quadratic term for temperature (T^2) was significant, suggesting the presence of an optimal thermal range for maximizing antioxidant retention.The quadratic regression model for DPPH radical scavenging activity of ripe jackfruit pulp, presented in its coded form, is given as follows:

DPPH radical scavenging activity of ripe jackfruit pulp (%) = $82.09-0.68T-0.36\ t-0.11\ T\ t-0.34\ T^2+0.069\ t^2$ …(4)

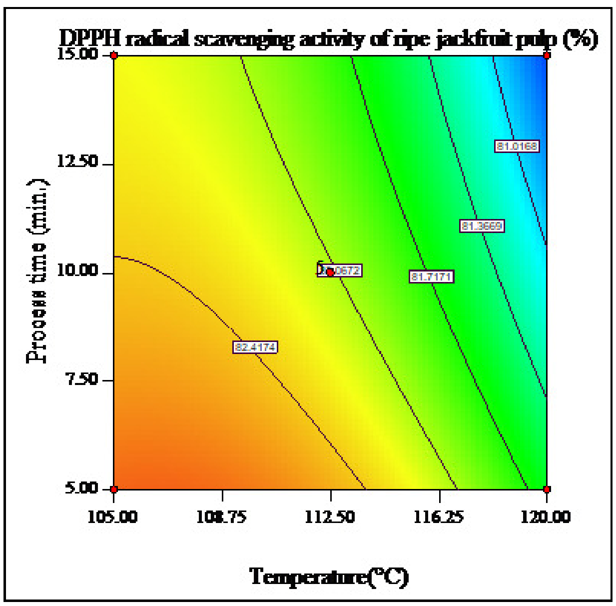

Fig 4: DPPH radical scavenging activity of ripe jackfruit pulp

3.5 Effect of retort processing on total sugar content in ripe jackfruit pulp

The total sugar content in processed ripe jackfruit pulp varied between 13.65±0.59% and 22.56±0.81%, with fresh pulp containing 22.56±0.81% before processing. A significant reduction in sugar content was observed post-retort processing, with the lowest recorded value (13.65±0.59%) occurring at 120 °C for 15 minutes (Fig.5). The decline in sugar content at higher temperatures may be attributed to thermal degradation or Maillard reactions, which can lead to caramelization and non-enzymatic browning (Goncalves *et al*., 2020) [5]. However, previous studies have shown that retort processing has a limited impact on total and reducing sugar levels in certain food matrices, such as Lactobacillus plantarum-fermented jujube juice (Zhang *et al*., 2022) [18].

ANOVA results confirmed that the models predicting sugar content changes were highly significant (*p*<0.0001), indicating that temperature (T) and time (t) are critical factors influencing sugar retention in retort processed jackfruit pulp. These findings underscore the necessity of optimizing retort processing conditions to minimize sugar loss while ensuring product safety and quality. The final equation in terms of coded factors is as follows: These insights contribute to the development of improved processing strategies for preserving the nutritional and sensory attributes of sterilized jackfruit-based products.

Total Sugar content in ripe jackfruit pulp (%) = $18.39-2.22*T_S-0.85*t_s-0.89*T_S*t_s-0.82*T_S^2+0.32*t_s^2$ …(5)

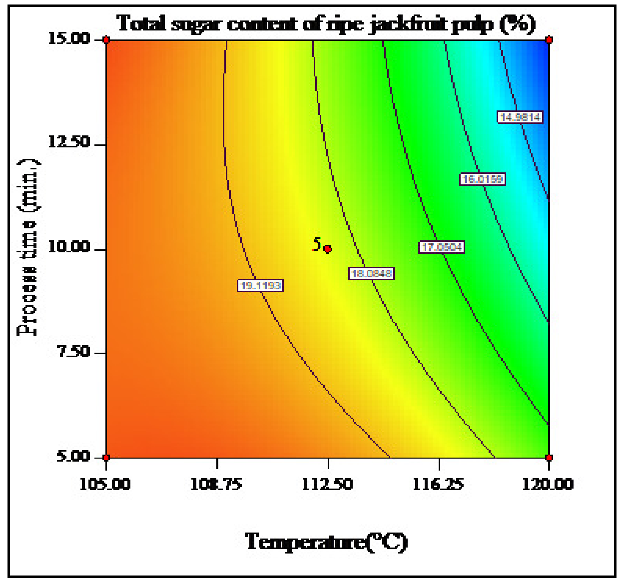

Fig 5: Total Sugar Content in Ripe Jackfruit Pulp

3.6 Microbial analysis of retort processed ripe jackfruit pulp

The microbial analysis of processed ripe jackfruit samples revealed that ripe jackfruit pulp showed a significant reduction in microbial population post-ptrocessing. According to the National Food Safety Standard for Beverages (Wang *et al*., 2017) [16], the acceptable limit for total aerobic mesophiles is less than 2 log CFU/g, and for yeast/mold, it is less than 1.3±0.03 log CFU/g. The control sample indicated initial microbial populations with total aerobic bacteria counts of 4.8±0.20 log CFU/g in ripe jackfruit pulp, and yeast/mold counts of 4.8±0.20 log CFU/g in ripe jackfruit pulp, which was above the standard safety limits, demonstrating a high risk of microbial contamination. Upon sterilisation at various temperatures and durations, total aerobic bacteria were not detected in most ripe jackfruit pulp samples, except for a few cases at 105 °C and 120 °C (Table.1), where minimal counts were observed. Yeast and mold counts were similarly reduced to non-detectable levels in most samples, with few exceptions at 105 °C and 120 °C. Notably, at 112.5 °C for 10 minutes, microbial populations in ripe jackfruit pulp were consistently undetectable, indicating that this condition is highly effective for sterilisation. These results highlight the efficacy of the sterilisation process in significantly reducing microbial loads in ripe jackfruit pulp, ensuring enhanced safety and shelf life of the product. This sterilisation treatment is critical for ensuring the safety and extending the shelf life of the product by effectively killing microorganisms through protein denaturation, metabolic enzyme inactivation, and DNA damage (Zhang *et al*., 2024) [17]. Bhat *et al*., 2017 [3] observed similar results in bottle guard juice in which microbial population (bacteria, yeast and mould) was below detection limit.

3.7 Optimization of retort processing parameters for ripe jackfruit pulp

The optimization of retort processing conditions for ripe jackfruit pulp aimed to identify the most effective combination of processing parameters to preserve key quality attributes. The optimal retort processing conditions were determined to be 106 °C for 5 minutes, yielding a desirability value of 0.956. Under these conditions, AA (11.03±0.38 mg/100 g), total phenolic content (68.53±3.14 mg GAE/g), total flavonoid content, and total sugar (20.07±0.69%) reached their highest levels, while microbial load remained below 1 log CFU/g.

These findings indicate that the optimized retort processing process effectively balances nutritional retention, sensory quality, and microbial stability, ensuring superior product quality. The comprehensive approach to process optimization highlights the importance of precise temperature and time control to maximize the preservation of bioactive compounds while maintaining food safety and extended shelf life.

Table 1: Microbial analysis of sterilized ripe jackfruit samples;

Sterilisation temperature (°C)	Process time (min.)	Total aerobic bacteria ripe jackfruit pulp (log CFU/g)	Yeast/mold in ripe jackfruit pulp (log CFU/g)
Control sample		4.8±0.20	4.8±0.20
105	5	9±0.31	7.05±0.25
120	5	10±0.38	9.65±0.35
105	15	11±0.41	10.47±0.34
120	15	ND	ND
102	10	7±0.25	6.03±0.28
123	10	ND	ND
112.5	3	8±0.32	6.8±0.27
112.5	17	ND	ND
112.5	10	ND	ND
112.5	10	ND	ND
112.5	10	ND	ND
112.5	10	ND	ND
112.5	10	ND	ND

ND: Not Detected

4. Conclusion

This study comprehensively evaluated the impact of retort processing on the physicochemical and bioactive properties of ripe jackfruit pulp and identified optimal processing conditions to preserve its nutritional quality. The findings revealed that retort processing led to a reduction in AA, TPC, TFC, antioxidant activity (DPPH), and total sugar, with higher temperatures and extended processing times accelerating nutrient degradation. Notably, the most significant losses were observed at 120 °C for 15 minutes, highlighting the detrimental effects of excessive heat exposure. Statistical analysis confirmed that temperature and time were the most influential factors, with quadratic temperature effects playing a crucial role in nutrient retention.

Process optimization identified 106 °C for 5 minutes as the ideal retort processing condition, yielding a high desirability value of 0.956. Under these conditions, AA (11.03±0.38 mg/100 g), TPC (68.53±3.14 mg GAE/g), and total sugar (20.07±0.69%) were maximized, while microbial load remained within safe limits (<1 log CFU/g). These results underscore the importance of fine-tuning retort processing parameters to balance nutritional integrity, microbial safety, and extended shelf life in processed jackfruit products.

Overall, this research provides valuable insights into the thermal stability of bioactive compounds in ripe jackfruit pulp and establishes a scientific basis for optimizing retort processing processes in fruit-based food systems. The findings can contribute to the development of high-quality, shelf-stable jackfruit products with enhanced nutritional and functional properties, supporting both industrial applications and consumer health benefits.

Acknowledgment

The authors acknowledge the ICAR National Fellow project, funded by ICAR, for supporting this research (Order No. F.No.Agri.Edn/27/09/NF/2017-HRD, dated 02.06.2017).

5. References

1. AOAC. Official methods of analysis. 16th ed. Washington, D.C.: Association of Official Analytical Chemists; 1990.
2. Baliga MS, Shivashankara AR, Haniadka R, Dsouza J, Bhat HP. Phytochemistry, nutritional and pharmacological properties of *Artocarpus heterophyllus* Lam (jackfruit): A review. Food Res Int. 2011;44(7):1800-1811.
3. Bhat S, Saini CS, Kumar M, Sharma HK. Effect of thermal and alternate thermal processing on bottle gourd (*Lagenaria siceraria*) juice. J Food Process Preserv. 2017;41(3):e12911.
4. Cilla A, Alegría A, de Ancos B, Sánchez-Moreno C, Cano MP, Plaza L, Clemente G, Lagarda MJ, Barberá R. Bioaccessibility of tocopherols, carotenoids, and ascorbic acid from milk-and soy-based fruit beverages: Influence of food matrix and processing. Journal of Agricultural and Food Chemistry. 2012 Jul 25;60(29):7282-7290.
5. Goncalves EM, Raposo I, Pinheiro J, Alegria C, Moldao-Martins M. Quality changes during thermal processing of two mixed formulas of fruits and vegetables pulps. Emir J Food Agric. 2020.
6. Lund MN, Ray CA. Control of Maillard reactions in foods: Strategies and chemical mechanisms. J Agric Food Chem. 2017;65:4537-4552. doi:10.1021/acs.jafc.7b00882.
7. Marinova G, Batchvarov V. Evaluation of the methods for determination of the free radical scavenging activity by DPPH. Bulgarian J Agric Sci. 2011;17(1):11-24.
8. Mercali GD, Schwartz S, Marczak LD, Tessaro IC, Sastry S. AA degradation and color changes in acerola pulp during ohmic heating: Effect of electric field frequency. J Food Eng. 2014;123:1-7.
9. Patel J, Parhi A, Al-Ghamdi S, Sonar CR, Mattinson DS, Tang J, *et al*. Stability of vitamin C, color, and garlic aroma of garlic mashed potatoes in polymer

packages processed with microwave-assisted thermal sterilization technology. Journal of Food Science. 2020 Sep;85(9):2843-2851.
10. Pérez-López AJ, López-Nicolás JM, Del Cerro I, Beltrán-González FE, Carbonell-Barrachina ÁA. Effects of preservation liquid on vitamin C, instrumental color, carotenoids, and sensory quality of canned satsuma mandarin. J Food Process Eng. 2011;34(5):1464-1484.
11. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. New Delhi: Tata McGraw-Hill Education; 1986.
12. Santhirasegaram V, Razali Z, Somasundram C. Effects of thermal treatment and sonication on quality attributes of *Chokanan* mango (*Mangifera indica* L.) juice. Ultrason Sonochem. 2013;20:1276-1282.
13. Saranya S, Pulissery SK, Boregowda SK, Jayachandran LE, Pandey H, Abdullah S. High-pressure processing of jackfruit (*Artocarpus heterophyllus* L.) shreds: Quality prediction and response surface optimization. J Food Sci Technol. 2024. doi:10.1007/s13197-023-05996-9.
14. Swami SB, Thakor NJ, Haldankar PM, Kalse SB. Jackfruit and its many functional components as related to human health: A review. Compr Rev Food Sci Food Saf. 2012;11(6):565-576.
15. Vallverdú-Queralt A, Medina-Remón A, Casals-Ribes I, Andres-Lacueva C, Waterhouse AL, Lamuela-Raventos RM. Effect of tomato industrial processing on phenolic profile and hydrophilic antioxidant capacity. LWT-Food Sci Technol. 2012;47(1):154-160.
16. Vallverdú-Queralt A, Medina-Remón A, Casals-Ribes I, Lamuela-Raventos RM. Is there any difference between the phenolic content of organic and conventional tomato juices? Food Chem. 2012;130(1):222-227.
17. Wan YP, Xu Y, Yang KL, Feng L, Zhao XH. Discussion on application of some standards of food safety risk monitoring. Food Control. 2017;73:3732-3736.
18. Zhang J, Cheng J, Li Z, Weng M, Zhang X, Tang X, *et al*. Effects of ultra-high pressure, thermal pasteurization, and ultra-high temperature sterilization on color and nutritional components of freshly-squeezed lettuce juice. Food Chemistry. 2024 Mar 1;435:137524.
19. Zhang L, Zha M, Li S, Zong W. Changes in some quality characteristics of jujube juice with enzymatic hydrolysis prior to *Lactobacillus plantarum* fermentation. J Food Meas Charact. 2022;16(4):3196-3207.