Summary and Conclusion

SUMMARY AND CONCLUSIONS

Jackfruit (*Artocarpus heterophyllus*) is recognised for its substantial nutrient density, comprising essential minerals and bioactive phytochemicals that confer various health benefits. Despite its potential, jackfruit's highly perishable nature poses a challenge, with substantial post-harvest losses due to inadequate storage and transportation infrastructure.

In this study, various advanced methodologies were employed to standardize the processing protocols for ripe jackfruit (*Varikka variety*), both in its bulb and pulp forms, with a focus on thermal techniques such as retort pouch processing and non-thermal techniques such as HPP and PL. For retort pouch processing, thermal treatments were carefully optimized through pasteurization, involving temperatures between 75-95°C for durations of 5-15 min, and sterilization, which ranged from 105-121°C for 5-15 min. These methods aimed to extend the shelf life of the fruit while ensuring microbial safety. On the non-thermal front, HPP was applied, using pressure levels between 300 and 600 MPa for 5-20 min. This technique preserved the fresh-like qualities of the jackfruit, including its texture, colour, and nutritional profile, while promoting the retention of bioactive compounds known for their health benefits. PL was also explored as an effective non-thermal method, utilizing a voltage range of 1-2.5 kV with 50-200 pulses, and maintaining a lamp-to-sample distance of 4-10 cm. During the preliminary study, a sample thickness of 1 mm was established as the standard for processing jackfruit pulp.

This study evaluated the effectiveness of three different processing techniques—retort pouch processing, HPP, and PL on ripe jackfruit, focusing on shelf-life extension, quality preservation, and food safety. The retort pouch processed ripe jackfruit samples (under both pasteurisation and sterilization treatments) exhibited significant differences in quality attributes such as colour, texture, AA, TFC, and TPC when compared to fresh samples. A significant reduction ($p<0.05$) in quality parameters was observed at elevated processing conditions (95°C/25 min. and 99°C/15 min.) in pasteurised and sterilised RJB and RJP. The elevation of a* and reduction in b* contributed to the higher total colour deviation in samples at higher process conditions due to Maillard browning. The results indicated that heating jackfruit pulp and bulbs to 99°C for 15 minutes led to a notable reduction in ascorbic acid content, with the RJP

experiencing a 33.72% decrease and the RJB a 23.56% decrease during pasteurisation and 41.60% in RJB and 20% in RJP respectively in sterilisation. Controlled heat treatments preserved desirable sensory characteristics in pasteurised and sterilised samples. The selection of the best processing method among the thermal and non-thermal techniques was primarily based on microbiological safety, followed by the retention of quality attributes in the processed samples. For retort pouch processing, the optimal conditions were determined to be pasteurization at 80°C for 5 minutes for ripe jackfruit pulp (RJP) and 80°C for 12 minutes for ripe jackfruit bulbs (RJB), yielding optimal desirability indices of 0.917 and 0.812, respectively. Sterilization at 106°C for 5 minutes (Desirability-0.956) for RJP and 106°C for 7 minutes (Desirability-0.825) for RJB was identified as the best treatment. This method offered a significant extension in shelf life, with processed pulp lasting up to 180 days, and ensured microbial safety. However, elevated temperatures led to heat-induced softening and pigment loss.

During the study the effect of applied pressure and holding time on different quality parameters of ripe jackfruit were studied. A significant increase in L* value observed in RJB and RJP resulted in the higher opacity of the product. The higher pressures not only maintained the fresh-like appearance of the fruit but also promoted cytoplasmic rupture and enhanced bioactive compound release resulted in a maximum AA content of 23% in RJB and 17% in RJP. In the case of HPP, the application of 600 MPa for 20 minutes extended the shelf life of ripe jackfruit bulb to 40 days, while 600 MPa for 15 minutes improved the retention of bioactive compounds in ripe jackfruit pulp. HPP at 600 MPa significantly reduced microbial populations in RJB and RJP, achieving log reductions of 6.4±0.23 and 5.93±0.068 log CFU/g, respectively, while maintaining total aerobic mesophiles within the allowable limit. A threefold increase in shelf life was observed for treated RJB compared to untreated samples.

During PL processing, a nonsignificant reduction in colour characteristics was observed, and higher dosages (2.5 kV/200 pulses kept at 4 cm lamp to sample distance) resulted in maximum AA degradation of 17%. The treatment at 2.4 kV with 94 pulses achieved a 5-log cycle reduction in both aerobic mesophiles and yeast and mold counts. Furthermore, increasing the treatment to 2.4 kV with 187 pulses resulted in microbial levels dropping below detection limits. The best results were achieved while applying

a voltage of 1.50 kV, 200 pulses, and a lamp-to-sample distance of 4.00 cm. This method effectively preserved the biochemical integrity of the jackfruit and ensured microbial safety, extending the shelf life of the processed pulp to over 30 days. A shear-thinning behaviour was observed in thermal processed and non-thermal processed RJP. Thermal and non-thermal process effectively inactivated the microorganisms to the below detection level in optimised samples. In conclusion, while non-thermal techniques like HPP and PL better preserve the quality and nutritional content of ripe jackfruit, retort pouch processing remains the most commercially viable option for ensuring long-term safety and shelf life.

Highlights

- Demonstrated that thermal and non-thermal processing effectively inactivated the microorganisms in optimized samples.
- The optimal pasteurisation conditions were established as 80°C for 5 minutes for ripe jackfruit pulp (RJP) and 80°C for 12 minutes for ripe jackfruit bulbs (RJB)
- Sterilisation at 106°C for 5 minutes for RJP and 106°C for 7 minutes for RJB was identified as the best treatment
- Retort pouch pasteurised and sterilised samples were shelf-stable and can be stored up to 150 and <180 days respectively.
- High pressure processed samples exhibited higher biochemical contents and maintained fresh-like quality in processed samples with higher sensory scores
- In the case of HPP, treatment at 600 MPa for 20 minutes effectively extended the shelf life of ripe jackfruit bulbs, while 600 MPa for 15 minutes enhanced the retention of bioactive compounds in ripe jackfruit pulp.
- PL helps to retain phenolic and flavonoid compounds at moderate dosages

- The optimal results in pulsed light (PL) treatment were obtained at a voltage of 1.50 kV, with 200 pulses and a lamp-to-sample distance of 4.00 cm
- Retort pouch processing technique shown to be commercially viable option for ensuring long-term safety and shelf life.

Future scope

- Further studies are needed for cost reduction and commercialization of HPP and PL
- Explore the possibility of improving the sensory quality of PL-processed ripe jackfruit pulp