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RESEARCH ARTICLE

Standardization of thermal process parameters of canned tender jackfruit

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ABSTRACT

Value addition of jackfruit (*Artocarpus heterophyllus* L.) is a key strategy to promote its trade. Many of the value added products of jackfruit are either sugar or oil based and not suitable for daily consumption. An alternative would be the consumption of tender jackfruit as vegetable. Thermal processing appeared to be a promising preservation method to ensure year round availability of tender jackfruit for vegetable purpose. The identification of suitable time-temperature combination is an essential pre-requisite for thermal processing. The present study focus on standardisation of time-temperature required for thermal processing of canned tender jackfruit. A total of four treatments related to pasteurisation (TP) and sterilisation (TS) namely, TP1 (90°C, F=8), TP2 (90°C, F=10), TP3 (100°C, F=8), TP4 (100°C, F=10), TS1 (110°C, F_0=1), TS2 (110°C, F_0=2), TS3 (121°C, F_0=1) and TS4 (121°C, F_0=2) were examined under two factorial completely randomised design framework. Duration of thermal processing was computed from heat penetration curve. Based on the results of both microbiological and quality attributes (texture, colour, pH, total soluble solids and crude fibre content), the study advocates the use of pasteurisation at 90°C for 19 minutes (TP2) or sterilisation at 121°C for 38 minutes (TS3) for thermal processing of canned tender jackfruit.

Keywords: Heat penetration, pasteurisation, sterilisation, tender jackfruit, thermal processing

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INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* L.) is an exotic seasonal fruit usually grown in tropical regions. It belongs to the plant family *Moraceae*. It is native to the rainforests of Western Ghats in India and grown abundantly in Kerala, Karnataka, Tamilnadu, West Bengal and Bihar states within the country. It is the largest edible fruit and has an appealing taste and flavour (John et al., 1992). It is an ample source of vitamins, minerals and calories. Moreover, its functional, medical and physiological benefits are well addressed (Swami et al., 2012; Jagadeesh et al., 2007). More importantly, jackfruit is organically grown (without application of chemical fertilisers or pesticides) in a very natural way. Despite its benefits, jackfruit remained under exploited till recent past (Mitra and Mani, 2000). However, the scenario has changed over the last decade. For example, very recently, the Government of Kerala has declared jackfruit as the official fruit of the state with a view to promote its organic and nutritious qualities at state, national and international levels. They endorse value addition of jackfruit as a key strategy to fetch the global market.

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Several value added products have been developed from jackfruit seed, mature and ripen fruit (Mondal, 2013). But, most of them are less preferred for daily consumption as they have either sugar or oil as main ingredients. Such products are not advisable for people with diabetes and hypertension. In this regard, the consumption of immature or tender jackfruit (about 60 days of maturity) as vegetable is a better alternative with its richness in potassium, little sugars. Also, ascorbic acid content of tender jackfruit is superior to that of seed and mature fruit (Jagtap et al., 2010). These advantages together with inherent nutritional values, characteristic meat like texture and fibre content made it a suitable vegetable for day-to-day consumption.

The seasonal availability and high perishable nature of tender jackfruit has limited its year round availability in the market (Bakhara et al., 2018). Implementation of food preservation techniques would be the possible solution to account for the aforesaid challenges. Several thermal and non-thermal techniques exists (Prokopov and Tanchev, 2007). Thermal processing is superior to non-thermal techniques with regard to cost of production and commercial scale application. Thermal processing has the potential to yield food products with more than 2 years of shelf life (Barrett and Lloyd, 2012). Thermal processing when used in conjunction with canning could achieve commercial sterility of products by mutual influence of heat (Iciek et al., 2006) and anaerobic condition within the cans (Montanari et al., 2018). Hence, thermal processing and canning may be chosen as an appropriate method of preservation of tender jackfruit for culinary purpose. The identification of suitable time-temperature combinations required for thermal processing and canning of tender jackfruit is a key aspect for their commercial application. Thus, the present study focus on the standardisation of thermal process parameters of canned tender jackfruit based on both microbiological and quality attributes.

MATERIALS AND METHODS

Sample preparation

This study was conducted using tender jackfruit samples (50-60 days maturity) of '*Varikka*' variety procured from the Instructional Farm of Kelappaji College of Agricultural Engineering and Technology, Malappuram (Kerala, India). Initially, the samples were washed, peeled and cut into pieces of almost uniform size. Then, they were dipped in 0.1% potassium metabisulphate solution (2 kg of solution per kg of sample) for 15 minutes to prevent browning (Molla et al., 2008). Later, the samples were blanched in boiling water (100^oC) for 1 minute with 0.3% citric acid as preservative (Pritty and Sudheer, 2012). After blanching, the samples were immediately cooled to room temperature.

Thermal processing

Thermal processing of tender jackfruit samples were performed in tin cans (900 ml volume, 11.5 cm height and 10 cm diameter). About 250 g of blanched sample was taken in a can and the remaining portion was filled with about 550 ml brine solution (2%) with provision of suitable headspace (7 mm). The cans were exhausted to remove residual air (Srivastava and Sanjeev, 1994) and cooled to room temperature after double seaming. Then, they were subjected to two different pasteurisation (90 and 100^oC) and sterilisation (110 and 121^oC) temperatures in a retort. At each temperature, the time required to attain desired lethality (F values 8 and 10 in case of pasteurisation and F_0 values of 1 and 2 for sterilisation) was also examined. Thus, a total of four treatments related to pasteurisation (TP) and sterilisation (TS) were examined viz. TP1 (90^oC, F=8), TP2 (90^oC, F=10), TP3 (100^oC, F=8), TP4 (100^oC, F=10), TS1 (110^oC, F_0=1), TS2 (110^oC, F_0=2), TS3 (121^oC, F_0=1) and TS4 (121^oC, F_0=2). Each treatment was performed in separate batches consisting of 12 cans. In addition, test cans equipped with thermocouple probe inserted through tender jackfruit pieces were also included with each treatment to record the core temperature (Sreenath et al., 2008). After thermal processing, the cans were cooled in cold water to a core temperature of about 30^{o}C to prevent the product from being overcooked. The heat penetration curve and the suitable time required to attain the desired lethality (F and F_0 for pasteurisation and sterilisation, respectively) value were determined using an Ellab recorder (model TM 9608) and associated VALSUITE software.

Microbiological analysis and commercial sterility test

The microbiological analysis was performed using serial dilution and plating method. Nutrient agar medium was used to culture bacteria and potato dextrose for fungus and yeast. Both pasteurised and sterilised cans were subjected to plate count method (Sreenath et al., 2008). In addition, commercial sterility test (IS2168, 1971) was performed for sterilisation treatments. For the purpose, six cans were randomly selected from each sterilisation batch. Three of them were incubated at 55^{o}C for 4 days and the remaining at 37^{o}C for 14 days. After the incubation period, the cans were opened under aseptic conditions and the samples were transferred to sterile thioglycollate broth tubes. A layer of sterile liquid paraffin wax was applied in each tube to create anaerobic conditions. The tubes were then incubated at 37^{o}C for 48 h and examined for the development of turbidity as an indicator of microorganism survival. Those tubes with no turbidity were incubated again for 48 h at 37^{o}C to ascertain sterility (Sreenath et al., 2008).

Quality evaluation

The study examined selected physical and chemical attributes of canned tender jackfruit. The former category consisted of both texture (firmness and toughness) and colour while total soluble solid (TSS), pH and crude fibre content constitute the latter category. The variability in these attributes across different treatments was examined by means of one-way ANOVA using SPSS software.

The samples were subjected to double compression texture measurements using Texture Analyzer (Stable Micro-System Ltd., UK), with trigger force of 0.5 kg (10 mm depth of penetration, velocity of 10 mm s^{-1}) using a 50 N load cell and equipped with a 5 mm diameter probe. Maximum peak force and area under force-distance curve were noted as they correspond to firmness and toughness, respectively (Gonçalves et al., 2007).

Hunter Lab colorimeter (Mini Scan XE Plus) and a Commission International de l' Eclairage (CIE) standard illuminant C was used to determine CIE colour space co-ordinates, L*, a*, b* values of thermal processed tender jackfruit samples. The deviation of colour (ΔE) of samples from the standard was also recorded (Gonçalves et al., 2007). A larger ΔE value denotes greater colour change from the reference material (Saricoban and Yilmaz, 2010).

Total soluble solid (TSS) was measured using a hand refractometer (Ranganna, 1995). The pH of the jackfruit samples was determined using a digital pH meter (YORCO pH meter, model: YSI–601) (Ranganna, 1995). Crude fibre content was estimated by the acid hydrolysis method (AOAC, 1976).

RESULTS AND DISCUSSION

Duration of thermal processing

Initially, the heat penetration of characteristics of all the treatments was examined. The heat penetration curve of TP2 and TS3 are shown in Fig. 1 and 2 respectively as illustrative examples of pasteurisation and sterilisation treatments. In case of TP2 (Fig. 1), the minimum time required to attain the desired lethality (F=10) was around 19 minutes while it was noted to be 38 minutes in case of TS3 to attain F_0=1 (Fig. 2). In the same manner, the minimum duration of thermal processing calculated from heat penetration curve of TP1, TP3, TP4, TS1, TS2 and TS4 was found to be around 17, 11, 12, 48, 54 and 44 minutes, respectively.

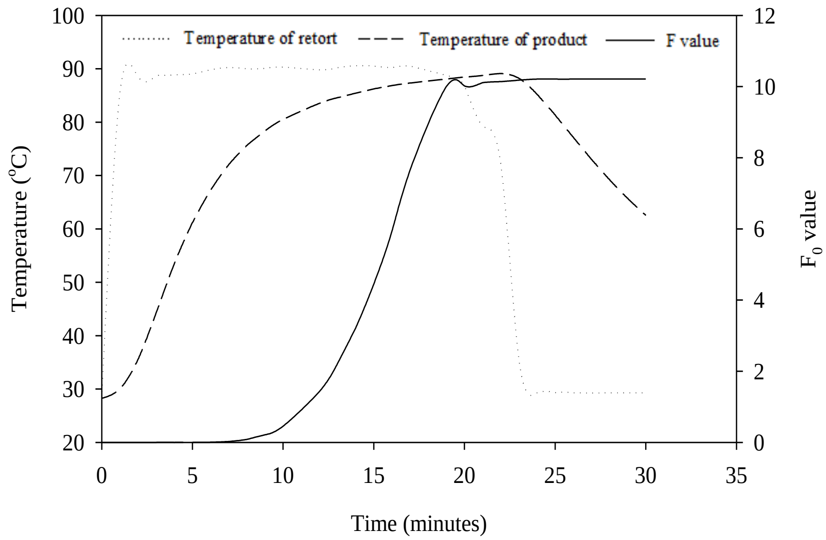

Fig. 1 Heat penetration characteristics of tender jackfruit subjected to pasteurisation at 90°C for *F* value 10.

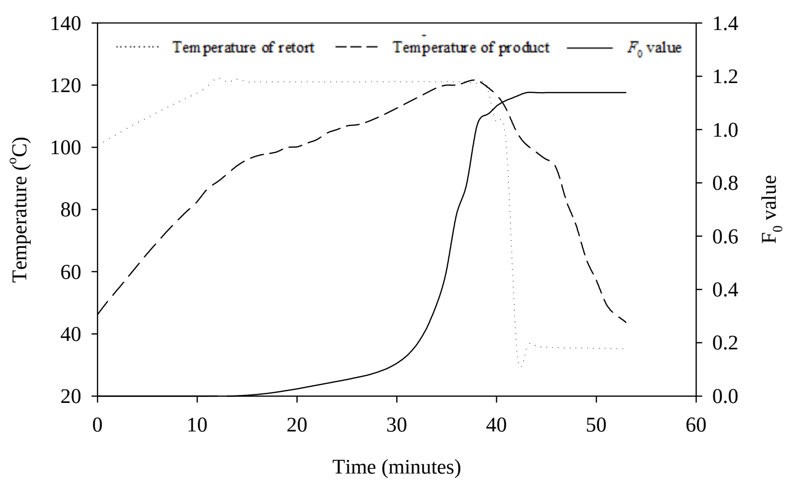

Fig. 2 Heat penetration characteristics of tender jackfruit subjected to sterilisation at 121°C for F_0 value 1.

Microbiological analysis of thermal processed canned tender jackfruit

All the pasteurisation treatments were found to be free of both fungal and yeast contamination as per the plate count method. However, bacterial growth was noted in case of TP1 (5×10^1 and 4×10^1 cfu/g at incubation temperatures of 55 and 37°C, respectively) and TP3 (4×10^1 cfu/g each at incubation temperatures of 55 and 37°C). All the sterilisation treatments showed no bacterial, fungal and yeast growth based on plate count method. The result of commercial sterility test revealed that TS1 has not attained the commercial sterility as indicated by the development of turbidity. Hence, those treatments namely, TP1, TP3 and TS1 which were found to be microbiologically unsafe were removed from subsequent analyses.

Physical attributes of thermal processed canned tender jackfruit

The texture and colour attributes of thermal processed tender jackfruit samples are shown in Table 1. The treatments subjected to pasteurisation yielded superior textural attributes as those subjected to sterilisation. Among the pasteurisation treatments, both the firmness and toughness of TP2 were found to be significantly higher than that of TP4. This is in line with the finding of Ali et al. (2005) that the texture profile parameters decrease with increase in time and temperature of thermal treatments. But contrasting result was obtained in case of sterilisation treatments in which TS3 (high temperature) yielded superior textural attributes than that of TS2 (low temperature). This may be attributed to the short duration of TS3 compared to that of TS2 although the temperature was higher in case of the former treatment. Similar observations were made by Kugino and Kugion (1994) and Ando et al. (1999).

Table 1 Quality attribute values of thermally processed canned tender jackfruit samples

Treatment	Physical attributes						Chemical attributes		
	Firmness (N)	Toughness (N.s)	L*	a*	b*	ΔE	#TSS (°Brix)	#pH	#Crude fibre (%)
Pasteurisation									
TP2	68.48^{a}	63.95^{a}	50.49^{a}	0.46^{a}	15.88^{a}	10.00^{a}	4.00	4.40	2.34
TP4	53.49^{b}	43.04^{b}	50.42^{b}	2.28^{b}	11.79^{b}	11.39^{b}	4.81	4.32	2.33
Sterilisation									
TS2	5.46^{b}	3.38^{b}	37.84^{b}	15.59^{b}	8.39^{b}	29.19^{b}	4.83	4.34	2.34
TS3	15.29^{a}	6.78^{a}	48.76^{a}	5.28^{a}	10.77^{a}	14.41^{a}	4.78	4.27	2.32
TS4	4.46^{b}	2.73^{c}	38.61^{b}	15.83^{b}	8.36^{b}	28.75^{b}	4.91	4.31	2.33

#Non-significant difference across pasteurisation and sterilisation treatments

It was found that thermal processing induced significant variations in colour of fresh tender jackfruit. A decrease in L* and b* values and an increase in a* value (lose of greenness) was noted during thermal processing (Ávila and Silva, 1999). The variation (in terms of ΔE) was higher in case of sterilisation than pasteurisation treatments (Table 1). Among the pasteurised treatments, the colour values of TP2 were relatively closer to fresh sample. The treatment TS3 showed a minimum ΔE value among sterilisation treatments.

Chemical attributes of thermal processed canned tender jackfruit

A slight decrement in the TSS value was noted for thermally processed samples (Table 1) when compared to that of fresh sample (5.01 °Brix). It may possibly be due to leaching of some of the soluble solids in water during thermal processing

(Javanmardi and Kubota, 2006). No significant difference in TSS values were noted across samples subjected to sterilised and pasteurised treatments.

The pH of thermally processed canned tender jackfruit was less to that of fresh sample (5.04) which may be related to the influence of temperature on pH reduction (Safdar et al., 2010). Within thermal processing treatments, no significant variation in pH was noted.

Thermal processing has little induced variation in crude fibre content of fresh tender jackfruit (2.16%). It remained stable during thermal processing (Rickman et al., 2007) hence yielded similar values across pasteurisation and sterilisation treatments. It may be noted in almost all instances that the fibre content appears to be lower in fresh tender jackfruit than in canned tender jackfruit. This may be due to browning reactions and related products (analysed as lignin) formed during thermal treatment (Chang and Morris, 1990).

Selection of best time-temperature combination

The selection of best treatment or time-temperature combination for thermal processing of canned tender jackfruit was based on combined results of microbiological and quality analyses. All the treatments except TP1, TP3 and TS1 were found to be microbiologically safe. With regard to texture and colour, the pasteurised samples outpaced those subjected to sterilisation while no significant (based on two factorial completely randomised design) variation in pH, TSS and crude fibre content was noted across the different thermal processing treatments. Among the pasteurisation treatments, TP2 (temperature=90^{o}C, F=10, time=19 minutes) yielded better results with regard to quality attributes. Hence, it was chosen as the best treatment irrespective of thermal processing methods.

One practical limitation associated with pasteurised products is that they require refrigerated (2–3^{o}C) condition for storage. On the contrary, sterilised products can be stored at ambient temperature and hence more economic and facilitates easy transportation than pasteurised counterparts. In this perspective, sterilisation would be a more attractive thermal processing method and we found it relevant to identify its best time-temperature combination. Based on the quality attribute values, TS3 (temperature=121^{o}C, F_0=1, time=38 minutes) was chosen as the best sterilisation treatment for thermal processing of canned tender jackfruit.

CONCLUSION

Pasteurisation outperform sterilisation with regard to physical and chemical attributes of canned tender jackfruit. But, pasteurised products require refrigerated condition for their storage. On the other hand, sterilisation has the potential to yield commercial sterile product which can be stored at ambient conditions. So, the selection of an appropriate thermal processing method rely on several factors including quality, cost and storage. The results of this study favour either pasteurisation at 90^{o}C for 19 minutes (TP2) or sterilisation at 121^{o}C for 38 minutes (TS3) as standardised time-temperature for thermal processing of canned tender jackfruit.

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