Journal of Food Engineering 91 (2009) 18–28

Contents lists available at ScienceDirect

Journal of Food Engineering

journal homepage: www.elsevier.com/locate/jfoodeng

Optimization of a multitarget preservation technique for jackfruit (*Artocarpus heterophyllus* L.) bulbs

Alok Saxena *, A.S. Bawa, P.S. Raju

Fruits and Vegetables Technology Discipline, Defence Food Research Laboratory, Siddarthanagar, Mysore 570011, Karnataka, India

ARTICLE INFO

Article history:
Received 25 April 2008
Received in revised form 24 July 2008
Accepted 1 August 2008
Available online 12 August 2008

Keywords:
Jackfruit
Bulbs
Osmotic dewatering
Response surface methodology
Multitarget preservation

ABSTRACT

Jackfruit (*Artocarpus heterophyllus* L.) bulbs in pitted and pre-cut form were subjected to a multitarget preservation technique involving water activity (a_w) regulation, acidification, and in-pack pasteurization as the hurdles. The osmotic dewatering process was optimized using response surface methodology with osmotic concentration, temperature, and duration of immersion as the process variables. Optimized conditions were found to be 65.9 °Brix, 68.5 °C temperature, and 180.6 minutes of immersion respectively for maximizing water loss, and overall acceptability while minimizing solid gain. Microstructural observations highlighted the maintenance of tissue integrity under the optimized process conditions. Total carotenoids retention in the product was found to be 64.2%, 46.2% and 35.7% under 6 °C, ambient (22–32 °C) and 37 °C temperature conditions respectively during storage. The overall shelf-life of multitarget preserved high moisture jackfruit bulbs was found to be 8, 6 and 4 months under the respective storage temperatures of 6 °C, ambient, and 37 °C.

1. Introduction

Jackfruit (*Artocarpus heterophyllus* L.) is a delicious tropical composite fruit with succulent and firmly textured bulbs. It is grown extensively in several tropical countries including the Indian subcontinent, southern China, southeastern Asian countries; middle Africa and Latin American countries (Samaddar, 1985). The fruit as such is a bulky with an average mass of 10 kg per unit (Jagadeesh et al., 2007). The fruit deteriorates rapidly upon ripening like other climacteric fruits. The edible portion in the form of bulbs after pitting is approximately 30–35% of the whole fruit. Therefore, the high transportation and packaging costs in case of whole fruits warrants marketing of the fruit in pitted and pre-cut form after the bulbs are separated from the pericarp.

Value addition during processing of jackfruit pulp has been carried out with regard to products such as a fruit bar (Manimegalai et al., 2001), fruit leather (Che Man and Sin, 1997) and canned juice (Seow and Shanmugam, 1992). The pitted bulbs have also been subjected to blast or cryo-freezing to extend the shelf-life (John and Narasimham, 1998). Certain Indian culinary preparations such as stabilized jackfruit curry were prepared from raw fruit (John et al., 1993). As such, the value added products reported from jackfruit are based on conventional processing methods such as dehydration, canning, and freezing, leading to impediment of the sensory attributes largely compared to a multitarget preservation technique.

Saxena et al. (2008) described a process protocol for extending the shelf-life of jackfruit bulbs through minimal processing coupled with modified atmosphere storage. The minimally processed product from jackfruit has been reported to have a shorter shelf-life and remain in a respiratory condition. As a result, the product was not completely shelf-stable. The physiologically active conditions resulted in restricted shelf-life. In order to make the product viable for a period of more than six months under ambient conditions, a multitarget preservation technique/hurdle technology could be adopted. The bulbs had a firm texture with no tissue disintegration and an acidic pH, making the product highly suitable for multitarget preservation.

A multitarget or combination preservation technique has been extensively applied to develop minimally processed as well as completely stabilized shelf-stable fruit products (Lopez-Malo and Palou, 2008; Jayaraman, 1998; Vink, 1994; Leistner, 1992). Leistner (1994) reported the advantages of using milder preservation hurdles in the development of novel shelf-stable products. The hurdles or individual entities of a multitarget preservation strategy could be water activity (a_w) regulation, acidification, mild heat treatment, with no emphasis on broad-spectrum antimicrobial agents and active packaging. Selection and magnitude of hurdles play an important role in achieving the microbial stability without impeding the vital nutrients and sensory properties of a multitarget preserved product (Vibhakara, 2007). An osmotic dewatering process is often used for reducing the a_w to a specific level to improve

* Corresponding author. Tel.: +91 821 2473290; fax: +91 821 2473468.
E-mail address: aloksaxena156@gmail.com (A. Saxena).

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doi:10.1016/j.jfoodeng.2008.08.006

Nomenclature

a_w	water activity
AT	ambient temperature
OAA	overall acceptability
OD	osmotic dewatering
ppm	parts per million
S_0	initial weight of solids (dry matter) in the sample (g)
SG	solid gain
β	regression coefficient
S_t	weight of solids (dry matter) in a sample after OD for a specific time t (g)
W_0	initial weight of sample (g)
WL	water loss
W_t	weight of the sample after OD for a specific time t (g)

the microbial stability of processed fruit products (Wiley, 1994). The a_w in the range of 0.90–0.93, has antibacterial effects and could be an effective hurdle in retarding bacterial growth. In addition to being an antimicrobial hurdle in synergy with others, marginal reduction in a_w may also improve the texture profile and color attributes.

There are no reports on the preservation of pitted and pre-cut jackfruit bulbs using multitarget preservation techniques. Hence, the present study was undertaken to optimize the osmotic dewatering process, the synergistic effect of hurdles such as a_w regulation, acidification, and in-pack heat treatment as well as to evaluate the stability of product under different storage temperatures.

2. Materials and methods

2.1. Raw material

About 200 kg ripe jackfruits of *firm variety* were procured with an average weight of 8–10 kg from the local fruit market at Mysore, India. The maturity of the fruit was ensured by selecting the fruits having brownish yellow color and wider gaps between the spiny portions of outer barky layer. Fruits with visible microbial infection or mechanical fissures were separated and the remaining fruits were surface sanitized with chlorinated water (100 ppm). The edible perianth portion in the form of bulbs was separated manually by slitting open the fruit using sharp edged stainless steel knives. The bulbs were pitted by giving vertical cut to remove the seed. Each pitted bulb was vertically cut in to uniform slices. The overall yield of the edible portion was found to be 35% in terms of pitted and pre-cut bulbs while the seeds constituted 12% of the whole fruit by weight. The pre-cut bulbs were subjected to a sanitary wash in chlorinated water (30 ppm). About 70 kg of pre-cut and surface sanitized bulbs was used for the processing.

2.2. Osmotic dewatering process

The osmotic dewatering (OD) process was optimized using response surface methodology (R.S.M.) through the central composite rotatable design (C.C.R.D.). The design was generated using commercial statistical package, Design-Expert version 7.1.3 (Statease Inc., Minneapolis, USA, Trial version). The experimental variables included osmotic solution concentration, temperature, and duration of immersion. Twenty experiments were carried out with different permutations of selected variable components. The ranges of values were 55–75 °Brix, 50–70 °C, and 150–210 min for osmotic solution concentration, temperature and immersion time, respectively (Table 1). The experimental format for the uncoded form of process variables was randomized (Table 2) to maximize the effect of unexplained variability in the observed responses due to extraneous factors. The different batches, consisting of 500 g each were subjected to osmo-blanching in sugar syrup at 85 °C for 5 min at defined concentrations using food grade commercial cane sugar as per the experimental format (Table 1) followed by assurance of other variables (temperature and immersion time) during the process. Individual samples were blanched in water at 100 °C for 5 min as well as in steam for 2 min to study the changes in microstructure. The fruit to solution ratio was kept as 1:5 to avoid an excessive dilution (Simal et al., 1997). The soak solution after osmo-blanching contained citric acid (0.3% w/v) (S.D. Fine chemicals Ltd., Mumbai, India), and potassium metabisulfite (0.05% w/v) (Qualigens, Mumbai, India) for acidulation and sulphitation of the product during the osmotic process. The different glass containers used during the optimization were constantly stirred using a stainless steel stirrer (150 rpm). At regular intervals during the osmotic process, samples were drawn and gently patted with absorbent paper to remove extra solution. Around 10 g of fresh as well as osmo-dewatered samples were used for the determination of dry matter and moisture content using overnight oven drying at 70 °C. The remaining material was used for the sensory evaluation.

The water loss (WL) and solid gain (SG) during OD were calculated using standard formulae:

Table 1
Experimental variables and their levels for CCRD in coded and uncoded form

	Symbols	−1.68	−1	0	1	1.68
Solution concentration (°Brix)	X_1	48.2	55	65	75	81.8
Temperature (°C)	X_2	43.2	50	60	70	76.8
Immersion time (min)	X_3	129.5	150	180	210	230.5

Table 2
Experimental design of process variables used in osmotic dewatering of jackfruit bulb slices

Run	Solution conc. (°Brix)	Temp (°C)	Immersion time (min)
1	55.0	70.0	210.0
2	65.0	60.0	180.0
3	75.0	50.0	210.0
4	65.0	60.0	230.5
5	75.0	50.0	150.0
6	65.0	60.0	180.0
7	55.0	50.0	210.0
8	55.0	50.0	150.0
9	65.0	60.0	129.5
10	65.0	60.0	180.0
11	75.0	70.0	210.0
12	65.0	76.8	180.0
13	65.0	43.2	180.0
14	75.0	70.0	150.0
15	65.0	60.0	180.0
16	81.8	60.0	180.0
17	65.0	60.0	180.0
18	55.0	70.0	150.0
19	65.0	60.0	180.0
20	48.2	60.0	180.0