



Enzymatic optimization for juice extraction from varikka jackfruit parts using a statistical approach

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Abstract

Comprised of peel or rind, unfertilized perigones and central core with edible hard and crispy fruit bulbs enclosing seeds. The underutilized parts constitutes 55 % of total fruit, which turns as food waste. The present study focused on the utilisation of these underutilized parts (rind and perigones) along with the edible bulbs, for the preparation of clarified juice with higher yield. Since, jackfruit is rich in pectin and some other polysaccharides, the enzymatic hydrolysis becomes an essential process, which is optimized here by Response surface methodology. Effect of enzyme treatment at varied enzyme concentration (0.1 to 0.8 %), incubation temperature (30 to 45 °C) and incubation time (1 to 5 hours) was studied by Second order Central Composite Face centred Design (CCF). The coefficient of determination, R² values for both *varikka* rind with perigones (VRP) and *varikka* bulbs (VB) were greater than 0.90, which signifies the correlation between the juice yield with enzyme concentration, incubation time and temperature. Based on response yield, the optimum condition for enzymatic hydrolysis of rind and perigones was 0.64 % -enzyme concentration at 3.54 hours' time and 42.78 °C temperature; whereas for fruit bulbs, it was 0.48 % *vlv* enzyme concentration at 2.87 hours' time, 39 °C temperature respectively. The enzyme treated juice at these optimal conditions exhibited significant increase in clarity, colour, TSS, acidity, flavonoids, phenols, tannins and antioxidant activity, whereas reduced values in viscosity and pectin was observed, compared with untreated (raw) juice components.

Key words: jackfruit, pectinase, underutilized parts, antioxidant activity, enzymatic hydrolysis, response surface methodology

Introduction

Jack fruit is one of the important underutilized fruits which is known for its therapeutic and nutritive value, with excellent flavour and attractive colour. Ripe jackfruit contains 7 to 15 per cent sucrose with distinctive aroma and taste. People are fond of jackfruit for its appetizing edible golden coloured ripe bulbs (Prakash *et al.* 2009) [23]. During processing, a large portion of jack fruit (including core, rind, undeveloped perigones and seeds) goes waste. These by-products, which are highly perishable and seasonal, are a problem with respect to its disposal (Rashmi *et al.* 2011) [24]. These underexploited parts can be processed into value added products.

Jackfruit juice obtained by minimal extraction are turbid, viscous and cloudy. Yield of such cloudy juice is low and is difficult for processing (Srivastava and Tyagi, 2013) [28]. Juice yield can be increased by applying various pre-treatments like cold, hot and enzymatic extraction methods. Enzymatic extraction method significantly increases the juice yield compared to other hot and cold extraction method (Joshi *et al.* 2012) [12].

Fruits are naturally rich in polysaccharide components like pectin, cellulose, hemicellulose etc. which makes the filtration process difficult. Pectinase treatment leads to breakdown of these high molecular weight pectin compounds into smaller fraction resulting in cluster formation, which improves juice recovery through centrifugation and filtration. Thus, the enzyme treated juice results in higher clarity with more concentrated flavour and

colour (Abdullah *et al.* 2007) [2]. Increase in yield with the positive changes in viscosity, pH, TSS and ascorbic acid in fruit juices have been reported by use of pectinase enzyme in Bael (Singh *et al.* 2012) [27], Dates (Abbes *et al.* 2011) [1], Tamarind variety Ajanta (Joshi *et al.* 2012) [12], Apricot and Pear (Joshi *et al.* 2011) [11], Banana (Lee *et al.* 2006) [17] and Blackcurrant (Mieszczakowska-Frac *et al.* 2012) [20].

Efficacy of pectinase treatment was affected by various factors like substrate and enzyme concentration, interaction time, temperature, pH of the mixture etc. These conditions can be optimized by the experimental design named as Response surface methodology (RSM). It is a cost effective method, which analyses the effect of individual variables along with its interactions on the response or dependent variables (Makebe *et al.* 2020) [18]. The present study is aimed at studying the effect of pectinase enzyme on the incubation time, incubation temperature and concentration of enzyme on *Varikka* jackfruit components (rind with perigone and bulbs) and optimizing the three variable conditions by Central Composite Design of RSM.

Materials and methods

Materials: Fully ripe fresh jack fruits of *varikka* type, without any defects were procured from the Instructional farm, College of Agriculture Vellayani (India). Healthy jackfruits were cut by the side of equatorial axis and the essential parts like edible fruit bulbs, unfertilized perigones, and a layer of spiky rind were separated. These parts were homogenized with water in the ratio of 1:2 to produce fine

slurry of the pulp. The fine slurry of both edible (bulbs) and underexploited parts (rind and perigones) were used for the enzymatic treatments.

Enzymatic studies: Commercial pectinase from *Aspergillus niger* (TCI 9032-75-1) was used for the enzymatic treatment of Jackfruit pulp. The pectinase enzymatic treatment was performed with the aim to optimize the environmental conditions like time, temperature and enzyme concentration for the production of juice with more per cent recovery. For each experiment, 100g of jackfruit slurry was subjected to different treatment conditions. The temperature of the enzymatic treatment was maintained to the desired level by water bath. At the end of treatment, the enzymes in the samples were inactivated by heating the suspension to 90°C for 5 to 10 min, in a water bath. The resultant juices were centrifuged and filtered *via* the Whatman number filter paper. The juice yield was calculated using the formulae,

$$\text{Percentage Juice yield} = \text{Volume of filtrate} / \text{Weight of the sample taken} \times 100.$$

Experimental design: For the enzymatic hydrolysis of jackfruit, Response Surface methodology was employed for optimization. The design expert 6.0 (Stat- Ease Inc., Minneapolis, MN, USA) software was used to determine ANOVA and coefficient of determination (R²). The independent variables for the treatments were the incubation time, X₁(1-5 hours), incubation temperature, X₂(30–45°C), and concentration of enzyme used, X₃ (0.1–0.8 v/v %). The ranges of these variables were based on the preliminary experiments conducted earlier. The dependent variable was

the yield of juice expressed in percentage. Central Composite Face Centred (CCF) design was employed to determine the optimal conditions of the critical factors. In this design, the axial points are placed on the face centres of the cube; therefore, each variable has only three levels instead of five in CCD, which were -1, 0 and +1 (Mammar and Chaker, 2013) [19]. These three variables were responsible for the mechanism of enzyme activity in the juice. The dependent variables were expressed individually as a function of the independent variables, known as response function. The axial distance α was chosen to be 1, and a set of 20 experiments was carried out:

$$\text{Formula applied for total no. of experiments} = 2^{(\text{no. of variables})} + 2 \times \text{no. of variables} + \text{central points}$$

Therefore, for three variables:
 Total no. of experiments = 2³ + 2 × 3 + 6 = 20

The three different levels for each experiment in coded form are prescribed as -1, 0 and +1

Table 1: Levels of variables for enzymatic hydrolysis of Jackfruit

Independent variables	Levels		
	-1	0	+1
Time (hr)	1	3	5
Temperature (° C)	30	37.5	45
Enzyme concentration (%)	0.1	0.45	0.8

The independent variables were time, temperature and enzyme concentration while the dependent variable was the total yield of juice.

The experimental design matrix in coded (x) form and at the actual level (X) of variables is given in Table 2.

Table 2: Experimental design of variables and values of experimental data for optimization of enzymatic hydrolysis of *Varikka* jack juice

Experiment no.	Coded variables			Uncoded / independent variables		
	x ₁	x ₂	x ₃	Time X ₁ (h)	Temperature X ₂ (° C)	Enzyme X ₃ (v/v %)
1	0	0	0	3	37.5	0.45
2	0	1	0	3	45	0.45
3	0	0	0	3	37.5	0.45
4	-1	1	1	1	45	0.8
5	-1	-1	-1	1	30	0.1
6	0	0	0	3	37.5	0.45
7	0	0	-1	3	37.5	0.1
8	0	0	1	3	37.5	0.8
9	-1	0	0	1	37.5	0.45
10	1	1	1	5	45	0.8
11	0	0	0	3	37.5	0.45
12	0	0	0	3	37.5	0.45
13	1	1	-1	5	45	0.1
14	-1	1	-1	1	45	0.1
15	0	-1	0	3	30	0.45
16	0	0	0	3	37.5	0.45
17	1	0	0	5	37.5	0.45
18	1	-1	1	5	30	0.8
19	-1	-1	1	1	30	0.8
20	1	-1	-1	5	30	0.1

The variance for each factor assessed was partitioned into linear, quadratic and interactive components and were represented using the second order polynomial function as follows

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 + b_{11}x_1^2 + b_{22}x_2^2 + b_{33}x_3^2$$

The coefficients of the polynomial were represented by b₀ (constant), b₁, b₂, b₃ (linear effects); b₁₂, b₁₃, b₂₃ (interaction effects) and b₁₁, b₂₂, b₃₃ (quadratic effects). The significance of all terms in the polynomial functions were assessed statistically using F-value at probability (p) of 0.001, 0.01 or 0.05. The regression coefficients were used to generate contour maps from the regression models. The three-

dimensional (3D) plots were generated by keeping one variable constant at the centre point and varying the other variables within the experimental range using design software. The effect of variables on the responses was explained by the model equation and counter plot diagram (Aydar, 2018) [5]. Effect of pectinase on quality indices of *varikka jackfruit* components (rind perigone and fruit bulbs) at the optimal condition were studied for their physical, chemical and bioactive properties.

Physical properties

- Turbidity (Hmid *et al.* 2016) [11], Clarity (Shah *et al.* 2015) [26] and Colour (Onkaraya, 2000) [22] were measured using spectrophotometer
- Viscosity was measured by Brookfield Viscometer. The unit of viscosity is Cp. (Bayod *et al.* 2008) [6].

Chemical properties

- pH of the sample was determined by the digital pH meter (Akesowan and Choonhahirun, 2013) [3].
- Total soluble solids (TSS) content was measured using refractometer of 0- 32 ° brix (Vaidya *et al.* 2009) [31].
- Titratable acidity was determined by neutralizing the acid present in a sample using a standard base sodium hydroxide (Sadasivam and Manickam, 2008) [25].
- Pectin content was determined as calcium pectate using the gravimetric method (Begum *et al.* 2014).

Bioactives and antioxidant activity

- Total flavonoids were determined by the Aluminium chloride assay method (Kalita *et al.* 2013) [14].
- The phenolic content was determined by Folin-Cioalteau (FC) assay method (Aryal *et al.* 2019) [4].
- Tannin content was determined by Folin –Denis method (Sadasivam and Manickam, 2008) [25].
- DPPH activity was determined by diphenyl-1-picrylhydrazyl (DPPH) scavenging assay (Chan *et al.* 2007) [8].
- Total antioxidant activity was estimated by phosphor-molybdenum method (Wan *et al.* 2011) [33].

Statistical analysis

A Duncan homogeneity test was carried out using SPSS Statistics 23.0 (IBM Corporation) to find out the significant difference between the *varikka* treatments at optimal condition.

Results and discussion

Response surface analysis of juice yield

Response Surface Methodology (RSM) Central composite design was employed for enhancing the juice yield of *Varikka* jackfruit. Effect of three variables (incubation time, incubation temperature, and concentration of enzyme) on the exploratory variables (yield) is mentioned in table 3.

Table 3: Effect of pectinase treatment on jackfruit juice from *Varikka* rind with perigones (VRP) and *Varikka* fruit bulbs (VB)

Experiment no.	Coded variables			Uncoded / independent variables		
	x ₁	x ₂	x ₃	Time X ₁ (h)	Temperature X ₂ (° C)	Enzyme X ₃ (v/v %)
1	0	0	0	3	37.5	0.45
2	0	1	0	3	45	0.45
3	0	0	0	3	37.5	0.45
4	-1	1	1	1	45	0.8
5	-1	-1	-1	1	30	0.1
6	0	0	0	3	37.5	0.45
7	0	0	-1	3	37.5	0.1
8	0	0	1	3	37.5	0.8
9	-1	0	0	1	37.5	0.45
10	1	1	1	5	45	0.8
11	0	0	0	3	37.5	0.45
12	0	0	0	3	37.5	0.45
13	1	1	-1	5	45	0.1
14	-1	1	-1	1	45	0.1
15	0	-1	0	3	30	0.45
16	0	0	0	3	37.5	0.45
17	1	0	0	5	37.5	0.45
18	1	-1	1	5	30	0.8
19	-1	-1	1	1	30	0.8
20	1	-1	-1	5	30	0.1

VRP-*Varikka* rind with perigones; VB- *Varikka* fruit bulbs

The yield of the VRP ranged from 64 to 75 per cent and for VB ranges from 69 to 76 per cent. Maximum per cent yield of VRP was observed in 3 hours, 37.5 ° C and 0.8 %v/v enzyme concentration and 3 hours, 37.5 ° C and 0.45 %v/v enzyme concentration for VB. Response surface model for

juice yield as a function of enzymatic extraction was assessed by multiple regression techniques. The analysis of variance (ANOVA) for *Varikka* jackfruit components demonstrated that the proposed quadratic model was highly significant with agreeable estimations of R².

Table 4: Analysis of variance [Partial sum of squares] for response surface quadratic model (*Varikka* Rind Perigone VRP)

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	158.3545	9	17.59495	71.94961	< 0.0001**	significant
A	16.9	1	16.9	69.10781	< 0.0001**	
B	4.9	1	4.9	20.03717	0.0012**	

C	67.6	1	67.6	276.4312	< 0.0001**	
A2	13.64205	1	13.64205	55.78532	< 0.0001**	
B2	4.142045	1	4.142045	16.93773	0.0021**	
C2	1.454545	1	1.454545	5.947955	0.0349**	
AB	0.5	1	0.5	2.04461	0.1832	
AC	0	1	0	0	1.0000	
BC	2	1	2	8.178439	0.0170**	
Residual	2.445455	10	0.244545			
Lack of Fit	1.112121	5	0.222424	0.834091	0.5765	not significant
Pure Error	1.333333	5	0.266667			
Cor Total	160.8	19				
R-squared	0.984792					
Adj R- squared	0.971105					
Pred R-squared	0.947076					
Adeq precision	29.75489					

** Significant at 5% level

Table 5: Analysis of variance [Partial sum of squares] for response surface quadratic model (*Varikka* bulbs VB)

Source	Sum of squares	Df	Mean square	F value	Prob > F	
Model	100.1682	9	11.1298	40.00908	< 0.0001**	significant
A	8.1	1	8.1	29.11765	0.0003**	
B	10	1	10	35.94771	0.0001**	
C	40	1	40	143.7908	< 0.0001**	
A2	0.005682	1	0.005682	0.020425	0.8892	
B2	6.568182	1	6.568182	23.61111	0.0007**	
C2	6.568182	1	6.568182	23.61111	0.0007**	
AB	0.5	1	0.5	1.797386	0.2097	
AC	0.5	1	0.5	1.797386	0.2097	
BC	2	1	2	7.189542	0.0230**	
Residual	2.781818	10	0.278182			
Lack of Fit	1.448485	5	0.289697	1.086364	0.4649	not significant
Pure Error	1.333333	5	0.266667			
Cor Total	102.95	19				
R-Squared	0.972979					
AdjR-Squared	0.94866					
Pred R-Squared	0.8000					
Adeq Precision	20.91439					

** Significant at 5% level A-Time, B-Temperature, C-Enzyme level.

The experimental values of "Prob > F" less than 0.0500 indicate that model terms are significant. The model F value 71.94 and 40.01 of VRP and VB indicates that the model is significant at 0.01 %. Linear effect of time, temperature and enzyme concentration of both VRP and VB was found to be significant. Quadratic variation for all three factors were significant in VRP, where temperature and enzyme concentration was significant in *Varikka* bulbs(VB). The interaction of temperature and enzyme concentration, the most influenced factors of pectinase treatment was significant in both VRP and VB. Singh *et al.* (2012) reported that temperature and enzyme play a major role in increasing the juice yield due to the fact that pectinase enzyme degrade the pectic compounds in the samples results in increased juice yield with low viscosity.

Lack of fit F value of 0.83 and 1.09 for *Varikka* rind perigones and *Varikka* bulbs implies that the lack of fit is non significant relative to pure error. Non significant lack of fit is found to be good to fit in model (Noordin *et al.* 2004)^[21]. The "Pred R-Squared" values are 0.947 and 0.800 was in rational agreement with "Adj R-Squared" of 0.971 and 0.948 of *Varikka* rind perigones and *Varikka* bulbs. "Adeq Precision" measures the signal to noise ratio. A ratio greater than 4 is desirable, which was found to be higher in both VRP and VB. ANOVA analysis showed that this proposed model was satisfactory with R² values 0.98 and 0.97, for VRP and VB which indicates that the empirical model fits

the actual data. Similar results were obtained by Ghosh *et al.* (2016)^[10] The experimental values of "Prob > F" less than 0.0500 indicate that model terms are significant. The model F value 71.94 and 40.01 of VRP and VB indicates The experimental values of "Prob > F" less than 0.0500 indicate that model terms are significant. The model F value 71.94 and 40.01 of VRP and VB indicates who optimized the enzymatic condition using pectinase for the increased production of jamun juice.

The second order polynomial equation for predicting the effect of independent variables (time, temperature and enzyme concentration) on dependent variable (juice yield) for *Varikka* rind perigones and *Varikka* bulbs are given below.

Final equation in terms of coded Factors

1. *Varikka* rind and perigones (VRP)

$$\text{Yield} = +72.49 + 1.30 * A + 0.70 * B + 2.60 * C - 2.23 * A^2 - 1.23 * B^2 - 0.73 * C^2 - 0.25 * A * B + 0.000 * A * C + 0.50 * B * C$$

2. *Varikka* bulbs (VB)

$$\text{Yield} = +74.62 + 0.90 * A + 1.00 * B + 2.00 * C - 0.045 * A^2 - 1.55 * B^2 - 1.55 * C^2 + 0.25 * A * B + 0.25 * A * C + 0.50 * B * C$$

From the above equation it is observed that increasing

enzyme concentration increase the juice yield, as it degrades the pectin binding and protein bonding. Fig 1 A represent the interaction effect of time and temperature at fixed enzyme concentration of VRP. Per cent yield depend on time and temperature, as shown by its linear and quadratic effect, that was significant and gave a curvilinear effect. Fig 2B represents the interaction effect of temperature and enzyme concentration at constant time. Increased incubation temperature along with high enzyme dosage affects the yield by hydrolysing some pectin related compounds. High heat breaks the pulp that is enough for juice extraction. Fig 3C implies the relationship of time and enzyme concentration on per cent yield. Similar increasing trend of yield was obtained by Yolmeh *et al.* (2017) who reported that the pectinase treatment lowers the water holding capacity that reduces viscosity, which leads to juice recovery at higher per cent.

Fig 2A shows the interaction of time and temperature on the juice yield of *Varikka* bulbs. The time and temperature shows significant effect in both linear and quadratic terms. Fig 2 B represents the 3D graph for time and enzyme concentration at fixed temperature. The high enzyme quantity and holding time, influence the juice yield by breaking the pectin related compounds. Fig 2C gave a perfect concave nature of the graph which implies that concentration of the enzyme has the main effect on the yield of the juice. The results are in line with the observation of Tapre and Jain (2014), who reported that higher level of pectinase treatment slowly increased the juice yield.

Optimization of processing variables

The effect of independent variables were optimised from the given experimental responses in terms of per cent yield. The optimised condition of time, temperature and enzyme concentration was 3.54 hours, 42.78 °C and 0.64 % vlv enzyme for *Varikka* rind with perigones (VRP) and 2.87 hours, 39 °C and 0.48 % vlv enzyme concentration for *Varikka* bulbs. The response function was calculated from the polynomial and the yield per cent of the optimised combination of VRP and VB are 74.04 and 75.23 respectively.

Singh *et al.* (2012) [27] recommended the optimized enzymatic condition for bael pulp as: 425 min incubation time, 47 °C incubation temperature and 0.5 per cent enzyme concentration. In another study, Kaur *et al.* (2009) [15] studied the effect of pectinase enzyme treatment in the juice yield of guava using Response surface methodology and the optimized condition were incubation time 7.27 h, incubation temperature 43.3 °C and enzyme concentration 0.70 mg/100 g guava pulp.

Dam and Nguyen (2012) [9] developed fermented beverage jackfruits latex like filament called rags. At first, the enzymatic pre-treatment was employed at varied concentration (0, 0.1, 0.15, 0.2, 0.25, 0.3, and 0.35) and temperatures (70, 80, 90 and 100°C) to increase the juice yield. The optimized conditions for maximum juice recovery were 0.3% enzyme at 90°C for 2.5 minutes.

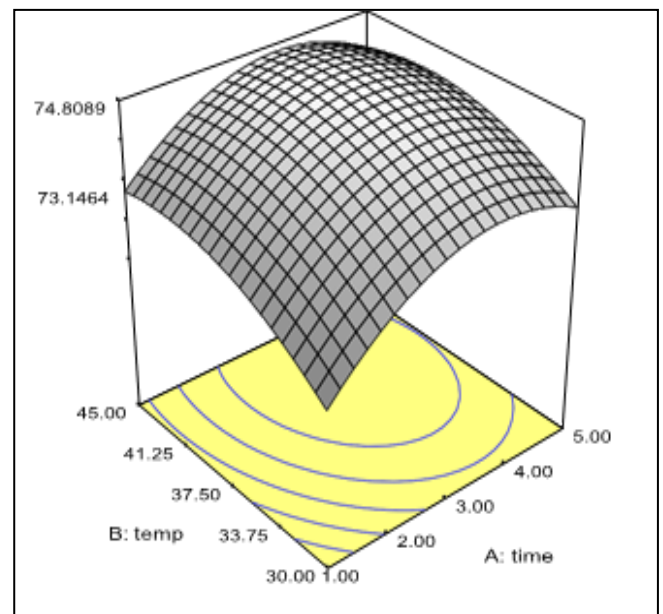


Fig 1 A: Response surface on juice yield showing the effect of temperature and time on per cent yield VRP;

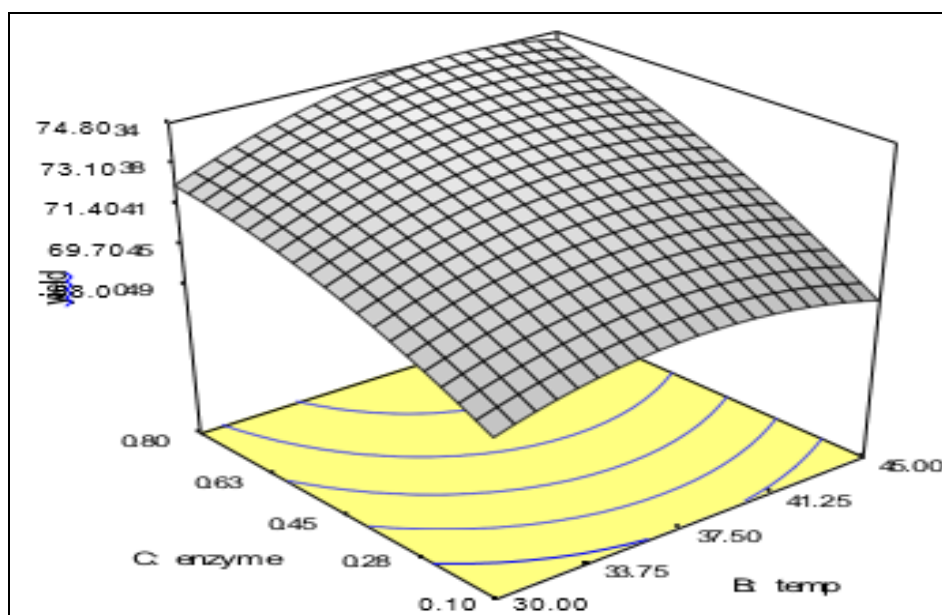


Fig 1 B: Response surface on juice yield showing the effect of temperature and enzyme on per cent yield VRP;

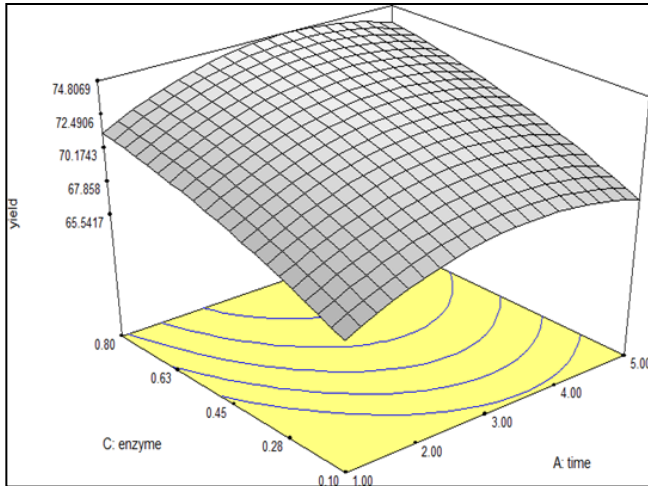


Fig 1 C: Response surface on juice yield showing the effect of enzyme and time on per cent yield VRP

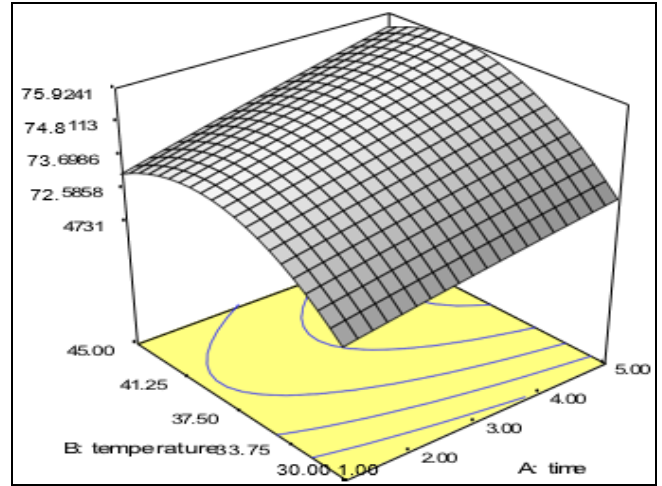


Fig 2 A: Response surface showing the effect of temperature and time on per cent yield VB;

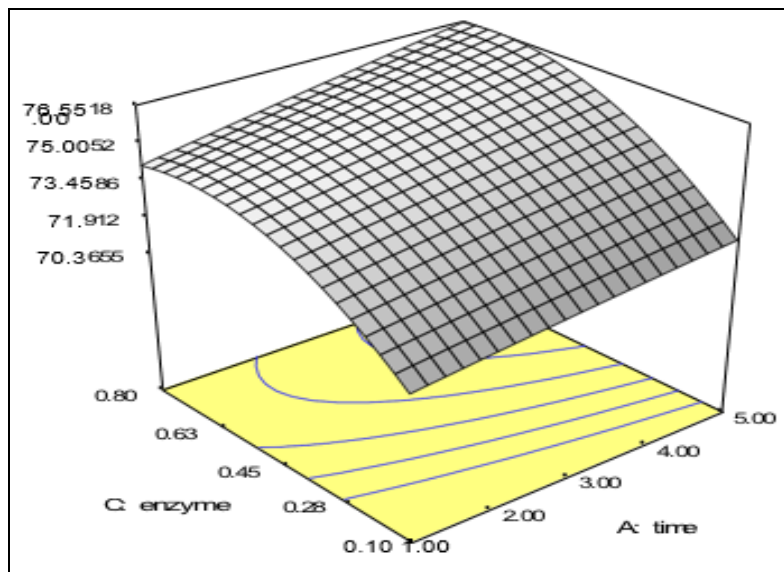


Fig 2 B: Response surface showing the effect of temperature and enzyme on per cent yield VB

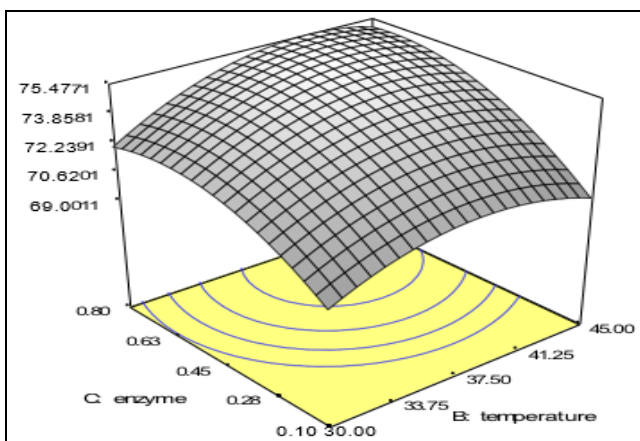


Fig 2 C: Response surface showing the effect of enzyme and time on per cent yield VB

Effect of enzymatic treatment at the optimal condition on the quality indexes of *Varikka* rind perigone and *Varikka* bulbs

Physical properties

Turbidity states the cloudiness nature of any fruit juices. The turbidity and clarity levels of *varikka* jackfruit

components after enzymatic hydrolysis was found to be significant at $p < 0.05$ (Table 6). The turbidity of VRP and VB juice sample after enzyme treatment was 0.57 and 0.33 whereas the clarity was 79% T and 84 % T respectively. Landbo and Meyer (2007) [16] reported that enzyme treatment degrade the high molecular pectin into smaller fractions, resulting the juice with reduced turbidity and increased clarity. The decrease in viscosity of enzyme treated samples was observed in rind with perigone (2.8 to 1.79) and bulbs (2.1 to 1.19) of *Varikka* type. The colour value of enzyme treated juice was found to be 0.31 and 0.25 OD Values of VRP and VB respectively. Similar result was observed in carambola juice treated with pectinase concentration of 0.1 per cent for 20 minutes at 30 °C temperature result in reduced viscosity of juice (Abdullah *et al.*, 2007) [2].

Chemical properties

Chemical properties like pH, TSS, Acidity and pectin were assessed (Table 7) in enzyme treated and untreated *varikka* components like rind perigone and bulbs. The significant decreasing trend was observed in pH and pectin whereas increased content was noted in TSS and acidity of enzyme

treated samples when comparing with untreated one. The pH of *varikka* type juice was in the range of 4.72 and 4.06 and that of the control was 5.6 and 4.71 of rind with perigone and bulbs respectively. The pectin content of the pre-treated VRP and VB juice was found to be relatively lesser in range (1.31-2.0 per cent) as compared to the juice of control having higher pectin (1.96-4.46 %). The increase in TSS was observed in VRP (4.9 to 5.5 ° brix) and VB (11.2 to 12.7 ° brix) in enzyme -treated *varikka*. Similar increasing trend was also noted in acidity levels of VRP (0.15 to 0.19 %) and VB (0.29 to 0.32 %). Hmid *et al.* (2016) [11] studied the efficacy of pectinase enzyme in the clarification of pomegranate juice. The quality of pectinase treated pomegranate juice was better when compared with untreated one. The decrease in pH was associated with increase in TSS and acidity. At 0.5 per cent pectinase concentration the pectin content was reduced to 2.23 from 2.37.

Bioactive properties

Effect of bioactive and antioxidant property of enzyme treated and untreated *varikka* components are depicted in table 8. The experimental results showed that the increase in bioactive properties was observed in all the enzyme treated samples compared with the untreated samples. The bioactive properties of *varikka* rind with perigone and *varikka* bulbs samples are as follow: flavonoid 4 to 4.53 mg QE/g and 2.98 to 3.24 mg QE/g; phenols 42 to 44mg GAE/g and 9.1 to 9.7 mg GAE/g; Tannins 70 to 77mg and 49 to 51.22 mg; DPPH 42.6 to 45.42 per cent and 24.2 to 28.40 per cent; Total antioxidant activity 40 to 43.4 per cent and 30 to 33.8 per cent respectively. Sun *et al.* (2007) [29] reported that enzyme treatment produced asparagus juice with high yield, phytochemical and antioxidant activity content.

Table 6: Effect of pectinase enzyme on the physical properties of *varikka* jackfruit components.

Physical properties	VRP		VB	
	Untreated	Pectinase treated	Untreated	Pectinase treated
Turbidity (OD Value)	1.25±0.29 ^d	0.570±0.00 ^b	0.98±0.01 ^c	0.337±0.00 ^a
Clarity (% T)	60±0.16 ^a	79.96±1.90 ^c	69±0.23 ^b	84.22±2.00 ^d
Viscosity (Cp)	2.80±0.01 ^d	1.79±0.01 ^b	2.10±0.06 ^c	1.19±0.00 ^a
Colour (OD values)	0.214±0.00 ^a	0.311±0.00 ^d	0.244±0.00 ^b	0.253±0.00 ^c

VRP- *Varikka* rind perigone ; VB- *Varikka* bulbs

^{a,b,c}Means with the different letter within the column are significantly different (P< 0.05). Values are Mean ± S.D (from 3 determinations)

Table 7: Effect of pectinase enzyme on the chemical properties of *varikka* jackfruit components

Chemical properties	VRP		VB	
	Untreated	Pectinase treated	Untreated	Pectinase treated
pH	5.60±0.02 ^c	4.72±0.11 ^b	4.71±0.14 ^b	4.06±0.08 ^a
TSS (° Brix)	4.9±0.03 ^a	5.5±0.02 ^b	11.2±0.06 ^c	12.7±0.30 ^d
Acidity (%)	0.15±0.00 ^a	0.19±0.00 ^b	0.29± 0.00 ^c	0.32±0.00 ^d
Pectin (%)	4.46±0.02 ^c	2.0±0.05 ^b	1.96±0.05 ^b	1.31±0.03 ^a

VRP- *Varikka* rind perigone ; VB- *Varikka* bulbs

^{a,b,c}Means with the different letter within the column are significantly different (P< 0.05). Values are Mean ± S.D (from 3 determinations)

Table 8: Effect of pectinase enzyme on the bioactive properties of *varikka* jackfruit components

Bioactive properties	VRP		VB	
	Untreated	Pectinase treated	Untreated	Pectinase treated
Total flavonoids (mg QE/g)	4.01±0.06 ^c	4.53±0.04 ^d	2.98±0.09 ^a	3.24±0.03 ^b
Total phenols (mg GAE/g)	42.43±1.15 ^b	44.56±1.45 ^b	9.11±0.24 ^a	9.70±0.15 ^a
Tannin (mg/g)	70.09±2.09 ^b	77.00±2.46 ^c	49.89±1.22 ^a	51.22±0.13 ^a
DPPH radical scavenging (%)	42.61±0.49 ^c	45.42±0.52 ^d	24.60±0.38 ^a	28.40±0.15 ^b
Total Antioxidant Activity (%)	40.45±0.90 ^c	43.47±0.26 ^d	30.12±0.30 ^a	33.82±0.43 ^b

VRP- *Varikka* rind perigone ; VB- *Varikka* bulbs

^{a,b,c}Means with the different letter within the column are significantly different (P< 0.05). Values are Mean ± S.D (from 3 determinations)

Conclusion

Response surface methodology allied with the Central Composite face centred Design (CCD) appeared to be a valuable tool for optimizing enzyme treatment of *Varikka* rind perigones and bulbs on response yield at different treatment condition like time, temperature and enzyme concentration. The optimum set of independent variables was obtained by contour plot graph to attain the desired levels of *varikka* jackfruit suitable for juice recovery. The experimental results indicated that the optimal enzymatic treatment condition for *Varikka* rind and perigones was 0.64 % enzyme concentration at 3.54 hours’ time and 42.78 ° C temperature whereas optimal condition for *varikka* bulb was 0.48 % *v/v* enzyme concentration at 2.87 hours’ time, 39 ° C

temperature respectively. The juice yield of *varikka* jackfruit components significantly increased with positive variants in physical, chemical, bioactive and antioxidant properties. Thus, the pectinase treatment is an useful technique for obtaining juice from *varikka* jackfruits underutilized parts (rind and perigone) and edible fruit bulb with high yield and phytochemical properties.

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