Hylocereus undatus fruit extraction on percent yield using Design-Expert software: a revelation for the enormousness of temperature and contact time

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Background
Dragon fruits (*Hylocereus undatus*) are popular edible fruits of desert and dry-land origin. They are rich in constituents. An attempt was made to find the optimum temperature and duration of exposure for the effective extraction of content from the fruits using Design-Export software.
Aim
This study aims to see what effect temperature and duration have on dragon fruit (*H. undatus*) extraction. According to the literature, numerous attempts have been made to extract components from fruits and other plant parts.
Materials and methods
The authors made an attempt to check if independent variables had an effect on the dependent response. The Design-Expert software was used to control the impact of the independent variable on the response during the experiment's design. Alternatively, samples were positioned, authenticated, and hauled out into the water, with independent factors (temperature and exposure time) affecting the response (percent yield).
Results and conclusions
According to the study, 40°C is the ideal temperature to extract the substance from the fruits, and the extraction and exposure times are directly proportional.

Keywords:
extraction, *Hylocereus undatus*, response, screening, variables

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Introduction

Natural plant substitutes have been extensively studied as an excipient in the pharmaceutical industry for decades [1]. Herbal products are primarily purchased by the pharmaceutical, nutraceutical, food, and cosmetic industries [2]. A lot of demand is there for botanical extracts as well as semifinished herbal products [3]. Plants of the desert stand out among the *Opuntia* species, namely *Hylocereus undatus* (common name: dragon fruit), which has been used in remedies since a past era [4–6]. *H. undatus* grows in the wild in South India. Additionally, it has a pear bush and bears fruit around the year. It is intended for dry areas and is designed to quickly absorb and store rainwater from uneven rains. Pads, joints, and fruits are all common terms for these plants' vegetative parts. The modified stems substitute the leaves in the photosynthetic process and have an ovoid or elongated shape. Water is mostly stored in the inner part, which is made up of white medullar parenchyma. When leaves produce spines, plants with prickly areoles grow on these rocks and have sharp edges, with pink, oval-shaped edible fruit. The extracting, phytochemical screening and biological screening of *H. undatus* fruits have been studied extensively. As well, using Design-Expert software, a comparison of temperature and time impacts on percent yield was conducted, despite previous studies not reporting any investigation.

Factorial design

Traditionally, outmoded research approaches generally study the sway of one variable at a time because it is feasible to manipulate it statistically. Even so, only one influencing factor can be studied simultaneously. As these two factors are interdependent, attempting to combine them will produce false results [7]. The design of experiments (DOE) is a component of multivariate analysis. Nevertheless, DOE is considered a treaty with some factors but not all. An objective of DOE is to

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screen responses and optimize them [8]. The imitations explore possible amalgamations of the levels of the factors. 'high' (+1) and 'low' (–1), and at both levels, all input factors are referred to as factorial design (FD) [9]. A fractional FD or Plackett–Burman design is preferred since the number of runs will be extremely augmented above five factors [10]. When there are four to five factors, the screening goal is FD, and the response surface goal is central composite design (CCD) or Box-Behnken Design (BBD). For screening factors containing five or more factors, FDs, or Plackett–Burman design are appropriate, followed by response surface goals [11]. The most widely used DOE software is Design-Expert/Statistica/Fusion/Minitab. The dependent variable is created by adding the independent variable to the desired output [12].

Materials and methods

Raw material

H. undatus fruits were collected from plants from the gardens cultivated in the areas surrounding Anantapur, Andhra Pradesh, India. A sample of fruits measuring 2×6 cm was collected. It was identified by the Department of Botany of Sri Krishnadevaraya University, Anantapur, and authenticated. An exemplar (SKBD/22/077) was deposited in the Herbarium.

Extraction of mucilage

Fruits from *H. undatus* were cleaned and poised for mucilage extraction. The pulp was manually separated from the medullar lining and crushed. To 100 g of pulp, 200 ml of water was added and heated on the heating mantle at 40–50°C for 60–90 min with stirring at 100 rpm. The mucilage was recovered from the filtrate after precipitation with ethanol (95%). As a result, 100 ml of the filtrate was then diluted with 200 ml of ethanol as well. The powder mucilage was obtained by drying at 40°C for 6 h. Extractions were duplicated three times [13–17].

Results and discussion

As mentioned earlier, mucilage can serve as an inexpensive and natural replacement for many industrial processes. Research is therefore needed to regulate its efficiency. Various extraction methods have been examined. A temperature and time impact has been evaluated.

Mucilage extraction

The mucilage yields from the fresh fruits using thermal extraction ranged from 60.2 to 62.6% (Table 1). According to the investigational design data and mucilage spelt out percentage found for each condition, quadratic polynomials were calculated for *H. undatus* fruits and validated by analysis of variance (ANOVA) analysis.

Initial risk assessment

Q8 and Q9 of International Conference on Harmonisation (ICH) state that the quality target-product profile (QTPP) is critical for quality by design. Additionally, it is crucial to separate unbiased viewpoints from biased ones at the beginning of the product-development process. A quality product must meet the QTPP's standards to be considered quality. The QTPP and Critical Quality Attributes (CQAs) for extraction are robust due to past investigations and appraisals of the literature.

Experimental design

In this study, a CCD was adopted for making and assessing quadratic response surfaces for screening the impact of temperature and exposure time (ET) on the extraction of contents from the fruits of *H. undatus*. Stat-Ease Inc., USA, used Design-Expert software (11.0) to assess the parameters. With the resultant quadratic model, the key, interface, and quadratic properties of independent variables on dependent variables were measured.

$$Y=B^{\circ}+B^{1}X^{1}+B^{2}X^{2}+B^{12}X^{1}X^{2}+B^{1}X^{12}+B^{2}X^{22}$$

Here, Y is the dependent variable, B°, B^{1}, and B^{2} are the regression coefficients of independent variables and their mutual interfaces, and X^{1} and X^{2} are the independent variables (temperature and ET). A dependent variable/response was the %yield of *H. undatus* fruits. The central composite experimental designs were expressed in Table 1.

Table 1 The experimental design by Design-Expert software for reviewing the impact of temperature and exposure time for the extraction of contents from the fruits of *Hylocereus undatus*

Trials	Factor 1 (A) time (min)	Factor 2 (B) temperature (°C)	Response (% yield)
1	60	40	61.7
2	90	40	62.6
3	60	50	60.4
4	90	50	61.6
5	53.7868	45	61.5
6	96.2132	45	62.3
7	75	37.9289	61.7
8	75	52.0711	60.2
9	75	45	59.7

Table 2 Fit summary for the response (% yield) of *Hylocereus undatus* fruits

Source	Sequential P value	Adjusted R^2	Predicted R^2	
Linear	0.0242	0.6141	0.3779	Suggested
2FI	0.7954	0.5438	0.2668	
Quadratic	0.0367	0.9160		Suggested
Cubic	0.5202	0.9318		

Variables (time and temperature) were tested using the response surface methodology. The optimum conditions for extracting mucilage were resolute by the maximum values of the response surface of the temperature and time curves. Stat-Ease-Design-Expert V.11 was used to create and estimate the untried designs. Statistical validation was performed using a one-way ANOVA with a 95% confidence level. Models were derived from a FD and star points were constructed from a constrained central composite design. The response from the reading was expressed as follows: Yield $=+60.80+0.4039A-0.5527B+0.0750AB+0.5875A^2+0.1125B^2$. For given levels of each factor, the equation can be used to envisage the response. In general, factors that are high in level are coded +1, and those that are low in level are coded −1. By comparing the coefficients of the factors, the coded equation can be used to regulate their relative importance. A quadratic and linear model for the response of %yield of *H. undatus* fruits was suggested (Table 2).

Additionally, the ANOVA for the quadratic model for the response (% yield) *H. undatus* fruits was shown in Table 3.

Having an F value of 18.44 indicates that the model is significant. There is only a 1.85% chance that an F value of this size will be considered significant if its P values less than 0.05 are significant. A, B, and A^2 are significant model terms. If the value is greater than 0.10, then the model terms must not be significant. If you have any insignificant variables, it may be beneficial to reduce model terms (excluding those necessary to support the hierarchy). The % yields from *H. undatus* fruits were embodied in Table 1.

For fresh fruits, the linear term for time has a positive coefficient, indicating that mucilage extraction increases over time. A minimum in the response surface indicates that large variations in time in either direction result in increased extraction yields (positive quadratic terms). While the linear term for temperature does not affect mucilage yield, the interface between the two variables controls the extent to which mucilage can be extracted. Large

Table 3 Analysis of variance for quadratic model for the response (% yield) for *Hylocereus undatus*

Source	Sum of squares	F value	P value
Model	5.11	18.44	0.0185
A – time	1.31	23.55	0.0167
B – temperature	2.44	44.09	0.0070
AB	0.0225	0.4060	0.5693
A^2	1.00	18.12	0.0238
B^2	0.0368	0.6643	0.4747

temperature variations either in the positive or negative direction increase extraction yield, as indicated by the quadratic terms. During the time range considered (60–90 min), mucilage extraction appears not to be significantly affected by time. Taking the sureness intervals into account, the interfaces between variables have no significant outcome on mucilage withdrawal. The interface impact of temperature and ET on the percent yield from the fruits of *H. undatus* (Fig. 1), whereas the contour plot and 3D response plots were represented in Fig. 2.

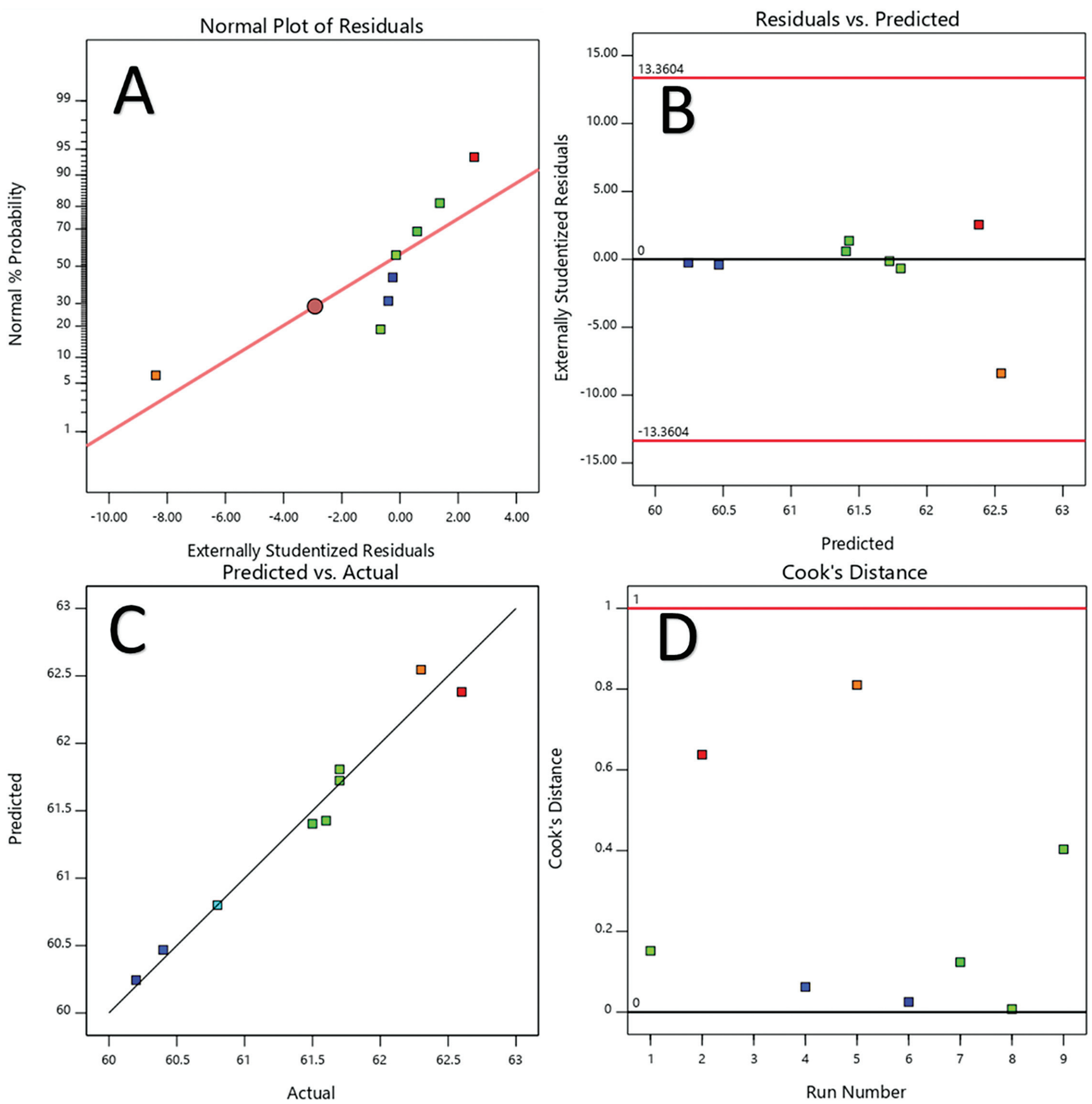
The effect of temperature and time on yield was resolute using response surface methodology. The maximum value of the response surface indicates the ideal situation for mucilage extraction. Using Stat-Ease-Design-Expert V.11 experimental designs were generated and evaluated using an ANOVA at a confidence level of 95%. By generating models with circumscribed central composite designs based on a FD with fewer star points, we created models with circumscribed star points.

To demonstrate a retort at dissimilar levels of each factor, the equation in the form of coded factors may be used. Coded equations can be used to control the percentage involvement of each factor in an outcome by comparing their constants. The high values of the factors are assumed to be +1 and the low values to be −1.

Conclusion

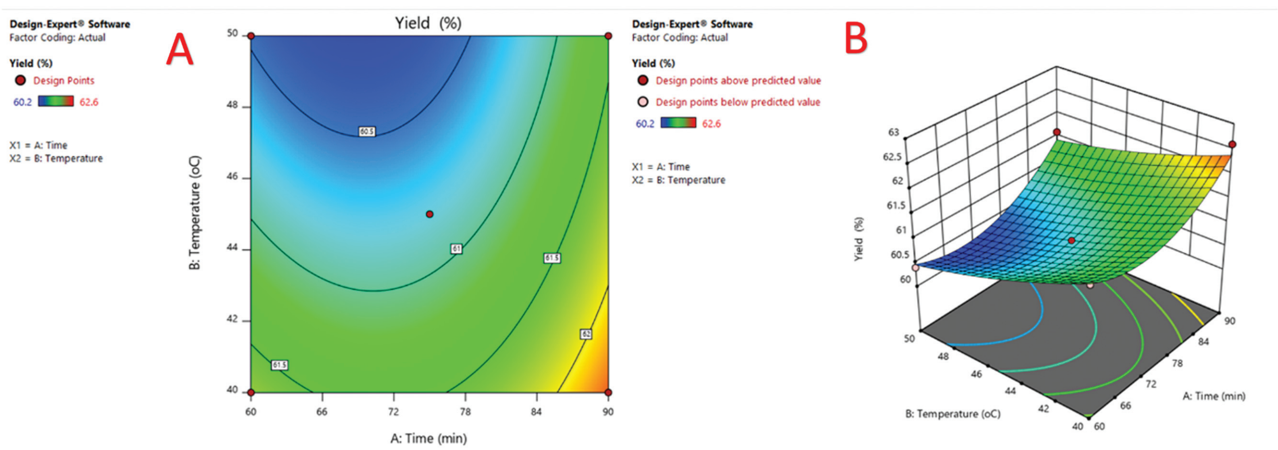
The design of the experiment was carried out using quality by design software called Design-Expert to decide the effect of temperature and ET on the

Figure 1



Plots showing the interface effect of temperature and exposure time on the percent yield from the fruits of *Hylocereus undatus*.

Figure 2



Contour plot (a) and 3D response surface plot (b) show the relationship between independent and dependent variables for *Hylocereus undatus* fruits under different temperatures and exposure times.

extraction of *H. undatus* fruits. The reading concluded that the fruits can be extracted at a temperature of 40°C and that the extraction was good as the ET increased.

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Conflicts of interest

There are no conflicts of interest.

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