Orclever Proceedings of Research and Development

https://doi.org/10.56038/oprd.v5i1.618

OR CLEVER Science & Research Group

Conference Article

Optimization Prickly Pear Juice Concentration Clarification for Better Retention of Potassium and Magnesium Properties

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4th International Conference on Design, Research and Development (RDCONF 2024)
December 19 - 20, 2024

Reference: Bozkurt, Abdik, E. (2024). Optimization prickly pear juice concentration clarification for better retention of potassium and magnesium properties. Orclever Proceedings of Research and Development, 5(1), 685-693.

Abstract

The prickly pear is a fruit naturally rich in antioxidants, vitamins, minerals, and other nutritional components. These characteristics make it a product with the potential to offer healthy beverage alternatives. The demand for healthy and natural products is rapidly increasing today, and consumers are gravitating towards products that do not contain additives and are made with natural ingredients. This growing demand can enhance the popularity of natural beverages such as prickly pear juice concentrate. Furthermore, prickly pear is a culturally significant local product in some regions, and offering such a product in concentrated form provides an opportunity to introduce the region's cultural heritage to a broader audience. Enzymes play a crucial role in producing clear and stable fruit juice. The aim of this study is to optimize the enzymatic clarification process parameters for prickly pear juice. This research aims to develop an appropriate processing technology for high-quality prickly pear juice production by ensuring better preservation of potassium and magnesium content.

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Prickly pear juice, in a cloudy form, was processed using different pectinase enzyme concentrations (50 ppm- 100 ppm), incubation temperatures (50–55°C), and incubation times (30–90 minutes). The effects of the enzymatic process on the clarity of the juice, as well as its potassium and magnesium content, were examined using the response surface methodology (RSM).

Response surface analysis determined the optimum conditions for the enzymatic purification process for prickly pear juice as follows:

- Enzyme concentration: 100 ppm
- Incubation temperature: 50°C
- Incubation time: 60 minutes

The expected results under these conditions are:

- Clarity: Ntu < 5
- Magnesium content: 9.35 mg/100 g
- Potassium content: 542.93 mg/L per juice

The desirability value obtained for these conditions was determined as 0.890. This value shows that the optimal process parameters provide a suitable balance to obtain the desired juice properties.

Keywords: Prickly pear juice, Potassium content, Magnesium content, Enzyme treatment

1. Introduction

Juice production stands as one of the most commonly employed process technologies within the fruit processing industry. Juices are highly valued for both their nutritional content and sensory attributes [1].Prickly pear juice, in particular, is regarded as a beneficial ingredient for sports and energy drinks, owing to its elevated amino acid content [2].The pulp exhibits a range of vibrant colors, including soft green, greenish-white, canary yellow, orange-yellow, lemon yellow, red, cherry red, and purple hues [3].These appealing colors are attributed to the presence of betalains, which consist of red-violet betacyanins and yellow-orange betaxanthins [4].In addition to its aesthetic qualities, prickly pear is also linked to various functional health benefits, such as boosting immunity, supporting bone and dental health, aiding digestive function, enhancing heart health, exhibiting anti-carcinogenic properties, providing antioxidant benefits, promoting weight loss, and reducing inflammation [5].Due to its color and nutritional benefits, prickly pear juice has become a valuable addition to fruit juice blends, such as orange-apple juice mixtures [6].

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The clarity and stability of fruit juices are primarily determined by the effective enzymatic breakdown of pectin [7].Treatment of fruit mash with pectinase enzymes leads to the degradation of the plant cell walls and middle lamella, resulting in increased juice yield [8].Enzymatic treatments using pectinase have also been shown to enhance juice yield and reduce turbidity in prickly pear juice [9].The colour of fruit juice is an important physical property and is affected by enzymes, degradation of ascorbic acid and the Maillard reaction. The latter rely on the presence of reducing sugars, proteins, and temperature [10].The enzymatic hydrolysis of pectic substances is influenced by various processing parameters, including enzyme type, hydrolysis time, enzyme concentration, incubation temperature, and pH [7]. Optimization of these parameters is crucial for achieving optimal juice clarity and color retent ion. For this purpose, optimization result on prickly pear juice clarification have been run using Response Surface Methodology (RSM). The aim of these studies is to evaluate the effect of enzymatic process parameters on the quality and color characteristics of clarified prickly pear juice and to optimize the process conditions using RSM.

2. Materials and Methods

The test preparatory was was carried out in the Doehler Karaman R&D Laboratory.

2.1.Raw Materials

In the study, prickly pear fruits naturally grown in two different locations of the Mediterranean region were used as materials. The collection sites of the prickly pears are as follows:

- Mersin-Silifke
- Mersin-Tarsus

The prickly pear fruits were harvested in the morning hours (09:00-12:00) without detaching them from their leaves, and transported to the laboratory on ice trays, where they were stored at +4°C until used.

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2.2.Processing and Extraction of Prickly Pear Juice

Fruits were hand-peeled and pulped in a stainless steel pul-per, in which it was screened through a 0.5 mm mesh screen toremove the seeds, then pressed through three layers of cheese-cloth to obtain clear prickly pear juice. (Juice yield was deter-mined in duplicate as g juice/100 g prickly pear pulps). 200 g prickly pear pulp was stirred with different concentrations(50 and 100 ppm) of pectinase respectively (pectinase enzyme (5000 Units; EC.3.2.1.15).These enzymes were derived from controlled fermentations by selected strains of Aspergillus niger (Sigma Chemical, St.Louis, MO, USA). Then, the enzyme-treated pulp was incu-bated in a water bath at 50 °C for 2 h. The enzyme-treated pulp was then placed in a boiling water bath for 5 min to inactivatethe enzyme. The enzyme-treated pulp was then rapidly cooled by cold water to 25 °C. Following the enzyme-treatment, theenzyme treated pulp was pressed through three layers of cheesecloth to obtain or extract clear prickly pear juice, then tested and analyzed immediately

2.3. Determination of Mineral Substance

Mineral elements in prickly pear fruit and its products, which were stored at -18°C until analysis, were measured in the solution obtained from samples that were wet-digested with HNO3 (4 mL) and H2O2 (3 mL) at 180°C in a Berghof MWS2 microwave system. A 0.5 g sample was used in the burning process, and at the end of the procedure, the final volume was adjusted to 50 mL with ultrapure water containing 0.03% HNO3. Potassium (K) was quantified using an Eppendorf Elex 6361 Flame photometer, while magnesium (Mg) was analyzed using a Perkin Elmer OPTIMA 2100DV ICP OES [11].

2.4. Experimental Design and Statistical Analysis

In this study, Design Expert 7.1.5.1 (Stat-Ease, Inc., Minneapolis, USA) Analysis Program was used for statistical evaluation of the data obtained and determination of optimum conditions with RSM. In addition,A three-factor, five-level central compound rotary design (CCRD) was performed using a quadratic model to investigate the interactive effects of enzyme concentration, incubation temperature, and incubation time on various response variables.Turkey-LSD multiple comparison test were performed using Statistica Package Statistical Program (ver. 8.0) for statistical evaluation of some physicochemical analysis results of the product produced under optimum conditions of the method.

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3. Result

Magnesium and potassium amounts of prickly fig fruits were investigated. Accordingly, the amount of potassium was at the highest values as in many fruits and vegetables. When the mineral substance amounts of the samples were compared, it was determined that the prickly fig fruits obtained from the Mersin-Silifke region were richer in terms of K and Mg than the other samples ($p<0.05$) (Table 3.1).

Table 3.1. Mineral substance amounts of prickly pear fruits (mg/kg)

Özellikler	K	Mg
Mersin - Silifke	1392,2±0,15a	348,9±0,91a
Mersin - Tarsus	833,5±0,40b	307,3±0,74b

**Aynı sütunda farklı harflerle gösterilen ortalamalar arasında istatistiksel olarak önemli düzeyde fark vardır (p<0,05)*

Mineral content of orange prickly pear (O. ficus indica) fruits, including Na at 758 mg/kg, K at 1567 mg/kg, Ca at 288 mg/kg, Mg at 231 mg/kg, Fe at 1.95 mg/kg, Cu at 0.396 mg/kg, Zn at 2.07 mg/kg, Mn at 3.06 mg/kg, Ni at 0.268 mg/kg, and Cr at 0.102 mg/kg [12]. A study conducted in Turkey indicated that the phosphorus content in prickly pear fruit juice ranged from 174.40 to 403.97 mg/kg, potassium content varied from 1908.10 to 3981.90 mg/kg, calcium content ranged from 136.79 to 1224 mg/kg, magnesium content varied between 205.15 and 393.01 mg/kg, and iron content ranged from 13.80 to 30.48 mg/kg [13]. The concentrations of macroelements in prickly pear fruit juices as follows: P (23.6-148.8 ppm), K (144.9-1020.6 ppm), Ca (371.4-2321.1 ppm), and Mg (8.2-995.9 ppm), while the microelements were detected as Fe (16.9-151.8 ppm), Zn (0.7-5.7 ppm), Mn (0.8-4.4 ppm), and Cu (0.1-5.9 ppm [14].

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Table 3.2. : Change of desirability function at optimum points determined by RSM.

Optimum Point	Temperature (°C)	Enzyme Conc. (ppm)	Time (min)	Mg	K	Desirability (D)
1	50,00	100	60	542,93	9,35	0,890-Seçilmiş
2	50,00	100	60	541,94	9,36	0,890
3	50,00	100	60	543,96	9,34	0,884

Enzyme concentration was found to have the most significant impact on processing costs among the various independent variables. In order to optimize the process, minimum enzyme dosage were used as criteria in numerical optimization and optimal working conditions were determined.The aims for the variants and responses, aimed at achieving optimal processing conditions, are summarized in Table 3.2. Under these conditions, the optimal treatment parameters were identified as 100 (ppm) enzyme concentration, an incubation temperature of 50°C, and an incubation time of 60 minutes. As a result of the analysis, it was revealed that fruit juice with a potassium content of 542.93 mg/L and a magnesium content of 9.35 mg/100 g could be obtained with the combination of enzyme dosage, incubation temperature and time.Use of these optimized conditions, tests were repeated to evaluate variations in the response variables. This suggests a high degree of agreement between observed and predicted values, confirming the accuracy and reliability of the regression models. The consistency between the observed and predicted responses further supports the validity of the developed model.

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4. Discussion and Conclusion

The commercial pectinase enzyme demonstrated excellent results in enhancing the clearly of prickly pear juice while prefable maintain other physical quality properties parameters. The evaluation of various process conditions for enzymatic process depend on all selected variables significantly influenced the clarity, magnesum, and potassium amount of the prickly pear juice. Quadratic polynomial equations effectively related the relationships between the processing and response variables. The response surface and contour plots facilitated the analysis of the interactives effects of process data on the response data, enabling the determination of optimal levels for enzymatic pretreatments. The optimal conditions for the clarifying of prickly pear juice can be suggested as follows: enzyme dosage of 100 ppm, incubation temperature of 50°C, and incubation time of 60 minutes. The findings from this study will be advantageous to the juice industry, particularly in improving the clarity of prickly pear juice while preserving its magnesium and potassium content.

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