NGUYEN TAT THANH

INFOGRAPHIC

TỐI ƯU HÓA QUÁ TRÌNH CHIẾT BROMELAIN TỪ PHỤ PHẨM DỨA BẰNG DUNG MÔI EUTECTIC SÂU KẾT HỢP SIÊU ÂM VÀ ĐÁNH GIÁ ĐỘ ỔN ĐỊNH CỦA DỊCH CHIẾT

Tác giả: Lê Ngọc Như Huỳnh
Đơn vị: Khoa Khoa học Ứng dụng & Công nghệ

Năm xuất bản: 2026

Tối ưu hóa quá trình chiết bromelain từ phụ phẩm dứa bằng dung môi eutectic sâu kết hợp siêu âm và đánh giá độ ổn định của dịch chiết © *2026* bởi **Lê Ngọc Như Huỳnh** đươc cấp phép theo **CC BY-ND 4.0.**

THE 9th NGUYEN TAT THANH UNIVERSITY
STUDENT RESEARCH WORKSHOP (NTTU-SRW)

OPTIMIZATION OF BROMELAIN EXTRACTION FROM PINEAPPLE BY-PRODUCTS USING DEEP EUTECTIC SOLVENT COMBINED WITH ULTRASOUND AND EVALUATION OF EXTRACT STABILITY

LE NGOC NHU HUYNH; ASSOC. PROF. DR. BACH LONG GIANG

ABSTRACT

Pineapple peel is a promising source of bromelain with potential for by-product valorization. This study aimed to optimize ultrasound-assisted bromelain extraction using a betaine–glucose deep eutectic solvent (DES) and evaluate extract stability during storage. The effects of DES concentration, ultrasonic intensity, and ultrasonication time on specific activity were investigated. Bromelain extracts obtained using DES and phosphate buffer were stored at 5, 15, 25, and 35 °C and evaluated for soluble protein content, enzyme activity, and specific activity. The results showed that lower storage temperatures better preserved bromelain stability, while DES provided greater stability than phosphate buffer. These findings demonstrate the potential of DES for bromelain extraction and stabilization from pineapple peel.

INTRODUCTION



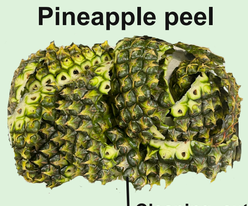
01 Rich source of bromelain
Proteolytic enzyme with varilous industrial and health applications

Bromelain

02 Valorization of by-products
Helps reduce agro-industrial waste and supports a circular economy

03 Potential for value-added products
Increases economic value and creates opportunities for sustainable development

MATERIALS AND METHODS



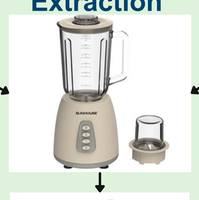
Pineapple peel

Cleaning, cutting and grinding

Phosphate buffer

DES

Extraction





Ultrasound-assisted extraction

Coarse filtration → fine filtration

Storage temperature

Pineapple Bromelain Extract

5°C | 15°C | 25°C | 35°C

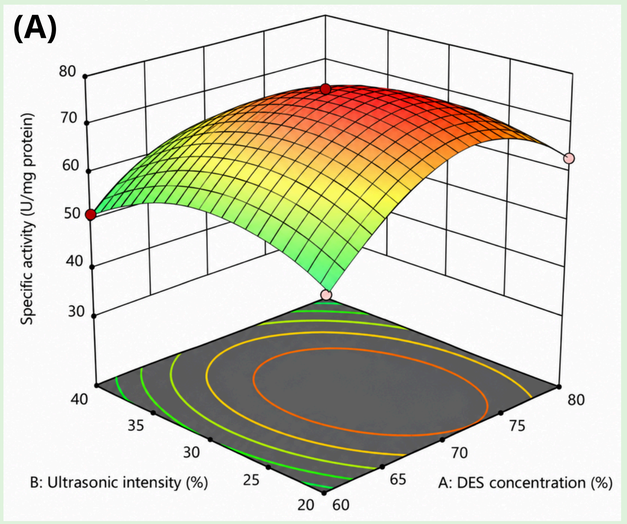
Chemical Analysis

Soluble protein | Enzyme activity | Specific activity

RESULTS AND DISCUSSION

1. Optimization of Bromelain Enzyme Extraction Conditions

Three-dimensional response surface plots showing the relationship between specific activity and three pairs of factors: (A) ultrasonic intensity (%) and DES concentration (%), (B) ultrasonication time (min) and DES concentration (%), and (C) ultrasonication time (min) and ultrasonic intensity (%).



2. Effect of Storage Temperature on the Quality of Bromelain Extract

Effect of Storage Temperature and Time on Soluble Protein Content

NADES							
Time (days)	5 °C	Time (days)	15 °C	Time (days)	25 °C	Time (days)	35 °C
0	0,56±0,03aB*	0	0,55±0,04aB*	0	0,56±0,03aD*	0	0,58±0,04aC*
3	0,55±0,02aB*	2	0,55±0,04aB*	1	0,55±0,03aD*	1	0,56±0,03aBC*
7	0,55±0,02Bb*	5	0,54±0,03aB*	3	0,55±0,03aD*	2	0,56±0,03aBC*
14	0,55±0,03Bc*	10	0,53±0,02Bb*	7	0,54±0,02abD*	3	0,54±0,03aBC*
21	0,53±0,03ABb*	15	0,52±0,03AB*	10	0,50±0,01bCD*	4	0,54±0,03BC*
30	0,52±0,02ABb*	21	0,52±0,03ABb*	14	0,46±0,02BbC*	5	0,51±0,02aBC*
45	0,51±0,03ABb*	30	0,50±0,02ABb*	21	0,41±0,02AaB*	7	0,49±0,04aB*
60	0,47±0,01A*	45	0,44±0,03Aab*	30	0,39±0,03AaB*	10	0,40±0,02Aa*
				45	0,38±0,02Aa	14	0,34±0,01Aa

Phosphate buffer							
Time (days)	5 °C	Time (days)	15 °C	Time (days)	25 °C	Time (days)	35 °C
0	0,45±0,03aB	0	0,44±0,03aE	0	0,43±0,02aC	0	0,44±0,02aC
3	0,44±0,03Bb	2	0,43±0,03bE	1	0,41±0,01aC	1	0,40±0,03aC
7	0,44±0,03Bc	5	0,42±0,02aDE	3	0,40±0,03bC	2	0,30±0,01aB
14	0,44±0,02Bb	10	0,39±0,04bCDE	7	0,38±0,02bC	3	0,29±0,02aB
21	0,43±0,01Bc	15	0,36±0,01CD	10	0,37±0,03bC	4	0,26±0,02B
30	0,43±0,02Bc	21	0,33±0,02BbC	14	0,29±0,02aB	5	0,25±0,02Bb
45	0,41±0,03Bb	30	0,28±0,02ABb	21	0,26±0,03aB	7	0,19±0,01Aa
60	0,30±0,03A	45	0,26±0,01Aa	30	0,18±0,01Aa	10	0,14±0,01Aa

Effect of Storage Temperature and Time on Enzyme Activity

NADES							
Time (days)	5 °C	Time (days)	15 °C	Time (days)	25 °C	Time (days)	35 °C
0	235,73±9,89aC*	0	233,66±15,91aD*	0	236,52±10,26aD*	0	245,50±13,76aD*
3	232,50±9,20bC*	2	230,75±21,37aD*	1	225,74±15,70aD*	1	225,60±18,09aD*
7	232,02±11,90Cc*	5	224,82±12,88bD*	3	211,65±13,52bD*	2	220,37±14,72aD*
14	224,77±14,65BCc*	10	211,40±9,95CcD*	7	179,10±16,62bC*	3	174,85±13,82aC*
21	216,90±12,91BCc*	15	202,23±15,44CD*	10	159,17±6,39bC*	4	173,56±10,79C*
30	212,45±9,64BCc*	21	180,92±9,22bC*	14	114,82±10,08Bb*	5	157,09±7,48aC*
45	197,29±14,98ABb*	30	134,23±7,32Bb*	21	99,85±6,33AaB*	7	121,89±12,87aB*
60	166,80±3,35A*	45	89,73±7,03Aa*	30	85,06±8,42AaB*	10	90,28±5,67aB*
				45	72,02±6,67Aa	14	44,55±2,82Aa

Phosphate buffer							
Time (days)	5 °C	Time (days)	15 °C	Time (days)	25 °C	Time (days)	35 °C
0	235,73±9,89aC*	0	233,66±15,91aD*	0	236,52±10,26aD*	0	245,50±13,76aD*
3	232,50±9,20bC*	2	230,75±21,37aD*	1	225,74±15,70aD*	1	225,60±18,09aD*
7	232,02±11,90Cc*	5	224,82±12,88bD*	3	211,65±13,52bD*	2	220,37±14,72aD*
14	224,77±14,65BCc*	10	211,40±9,95CcD*	7	179,10±16,62bC*	3	174,85±13,82aC*
21	216,90±12,91BCc*	15	202,23±15,44CD*	10	159,17±6,39bC*	4	173,56±10,79C*
30	212,45±9,64BCc*	21	180,92±9,22bC*	14	114,82±10,08Bb*	5	157,09±7,48aC*
45	197,29±14,98ABb*	30	134,23±7,32Bb*	21	99,85±6,33AaB*	7	121,89±12,87aB*
60	166,80±3,35A*	45	89,73±7,03Aa*	30	85,06±8,42AaB*	10	90,28±5,67aB*

Effect of Storage Temperature and Time on Specific Activity

NADES							
Time (days)	5 °C	Time (days)	15 °C	Time (days)	25 °C	Time (days)	35 °C
0	420.89±7.43aD*	0	422.48±2.26aE*	0	425.21±5.17aE*	0	422.25±5.19aF*
3	419.56±2.16CcD*	2	420.18±7.12bE*	1	407.52±4.30aE*	1	401.05±10.56aE*
7	418.81±8.68CcD*	5	418.54±5.17bE*	3	381.84±5.54bD*	2	390.32±3.85aE*
14	410.47±4.22CcD*	10	395.42±3.28cD*	7	330.82±18.59bC*	3	320.73±8.81aD*
21	407.43±2.12CcD*	15	386.79±6.58D*	10	316.70±7.11bC*	4	319.54±4.22D*
30	406.19±4.86Cc*	21	351.46±4.90bC*	14	251.70±10.59Bb*	5	305.81±5.46aD*
45	390.44±3.73Bc*	30	270.54±2.11Bb*	21	241.39±4.93aB*	7	250.44±6.89aC*
60	352.18±1.79A*	45	205.85±2.11Ab*	30	215.23±3.03Aa*	10	223.55±3.17aB*
				45	191.77±6.31Aa	14	129.22±3.82Aa

Phosphate buffer							
Time (days)	5 °C	Time (days)	15 °C	Time (days)	25 °C	Time (days)	35 °C
0	45.28±2.62aC	0	48.30±3.10aE	0	45.32±3.97aD	0	45.24±2.80aE
3	44.26±2.09bC	2	46.28±3.30bDE	1	44.30±0.83aD	1	40.15±1.06bD
7	44.03±2.56Cc	5	45.39±3.31bDE	3	42.09±1.99bD	2	38.33±1.00aD
14	43.47±1.16bC	10	41.42±2.16cD	7	35.85±1.06bC	3	31.66±0.22aC
21	41.20±2.75BbC	15	31.56±1.25C	10	34.28±2.30bC	4	30.71±0.49C
30	40.38±2.19BCc	21	28.64±2.00aBC	14	25.25±2.05aB	5	25.05±0.95aB
45	36.38±2.19Bb	30	24.24±1.00Bb	21	24.28±2.30aB	7	23.37±0.19aB
60	28.52±2.08A	45	14.03±1.22Aa	30	14.33±1.22Aa	10	11.78±0.19Aa

CONCLUSION

The stability of bromelain-containing pineapple peel extracts was strongly affected by storage temperature and extraction medium. Storage at 5 °C was the most favorable among the investigated temperatures for maintaining soluble protein over extended storage. The NADES system retained higher soluble protein than phosphate buffer throughout storage, with the advantage becoming more evident at elevated temperatures. These findings support the potential of betaine–glucose DES/NADES as both an extraction medium and a protective environment for bromelain, while emphasizing the importance of refrigerated storage for preserving extract quality.