OPTIMIZING THE EXTRACTION OF BIOACTIVE COMPOUNDS FROM GYNOSTEMMA PENTAPHYLLUM USING RESPONSE SURFACE METHODOLOGY (RSM)

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ABSTRACT

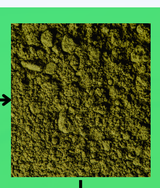
Gynostemma pentaphyllum, a medicinal herb of the Cucurbitaceae family with historical significance in Asian traditional medicine, was investigated for the optimization of bioactive compound extraction. This study employed Response Surface Methodology (RSM) utilizing a Central Composite Circumscribed (CCC) design, comprising 17 experimental runs with triplicate replication at the central point, to assess the effects of ethanol concentration (50-80%), extraction temperature (60-80°C), and extraction time (90-150 min) on the extraction efficiency of bioactive compounds. The optimal parameters were determined to be an ethanol concentration of 80%, an extraction temperature of 80°C, and an extraction time of 115 min. Under these conditions, the obtained contents of polyphenol, saponin, saponin, chlorophyll, antioxidant activity, and the obtained extraction yeild reached 0.51 ± 0.01 mg GAE/g, 8.26 ± 0.001 mg OA/g, 0.11 ± 0.0001 mg/ml, 1.54 ± 0.08 mg Vitamin C/g, and 21.53%, respectively. Model validation through three replicate experiments at the optimized conditions demonstrated no statistically significant difference ($p > 0.05$) between experimental and predicted values, confirming the model's reliability.

INTRODUCTION

Figure 1: Gynostemma pentaphyllum

MATERIALS AND METHODS

a moisture content below 12%



less than 2mm

Optimizing the extraction of bioactive compounds from Gynostemma pentaphyllum using response surface methodology (RSM)

Table 1: Optimization treatments

Runs	Variables		
	X1 (%)	X2 (minutes)	X3 (oC)
1	50	90	60
2	80	90	60
3	50	150	60
4	80	150	60
5	50	90	80
6	80	90	80
7	50	150	80
8	80	150	80
9	39.77	120	70
10	90.23	120	70
11	65	69.54	70
12	65	170.46	70
13	65	120	53.18
14	65	120	86.82
15	65	120	70
16	65	120	70
17	65	120	70

- Extraction yield (EY)
- Total saponin content (TSC)
- Total phenolic content (TPC)
- Total chlorophyll content (TCC)
- Antioxidant capacity (AC)

Diagram Experimental design

RESULTS AND DISCUSSION

Table 2: Results of optimization treatments affecting the extraction process

Runs	X1 (%)	X2 (minutes)	X3 (oC)	TPC (mg GAE/g)	EY (%)	TSC (mg OA /g)	TCC (mg/g)	AC (mg VitaminC/g)
1	50	90	60	0.36	4.13	1.68	0.02	0.79
2	80	90	60	0.35	18	3.51	0.09	1.32
3	50	150	60	0.36	4.31	1.44	0.02	1.33
4	80	150	60	0.37	15.41	3.04	0.08	1.48
5	50	90	80	0.49	5.13	3.58	0.02	1.58
6	80	90	80	0.49	17.73	3.87	0.1	1.24
7	50	150	80	0.46	6.46	3.78	0.03	2.02
8	80	150	80	0.48	16.42	3.82	0.09	1.31
9	39.77	120	70	0.41	2.21	3.14	0.01	1.22
10	90.23	120	70	0.41	21.28	4.72	0.11	1.06
11	65	69.54	70	0.38	10.92	3.77	0.05	1.51
12	65	170.46	70	0.37	10	3.53	0.05	2.02
13	65	120	53.18	0.39	9.55	2.55	0.05	1.17
14	65	120	86.82	0.59	12.77	4.81	0.07	1.68
15	65	120	70	0.49	21.92	14.74	0.07	2.39
16	65	120	70	0.49	22.1	14.3	0.07	2.39
17	65	120	70	0.48	22	15.45	0.07	2.41

The p-value in the ANOVA analysis for each component in the model was less than 0.05, indicating that the polynomial models are statistically significant. Ethanol concentration, extraction time, and temperature had the greatest impact on the investigated bioactive compounds, especially TPC.

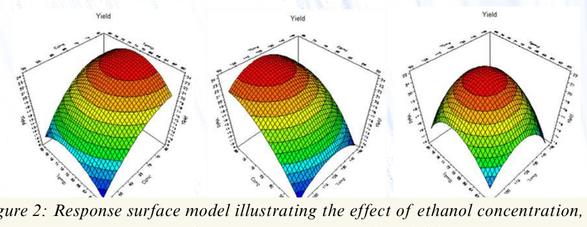


Figure 2: Response surface model illustrating the effect of ethanol concentration, time, and temperature on extraction yield

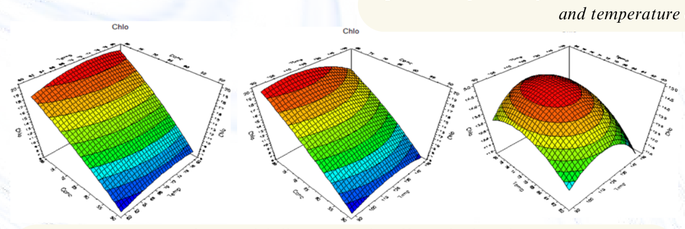


Figure 3: Response surface model illustrating the effect of ethanol concentration, time, and temperature on chlorophyll content

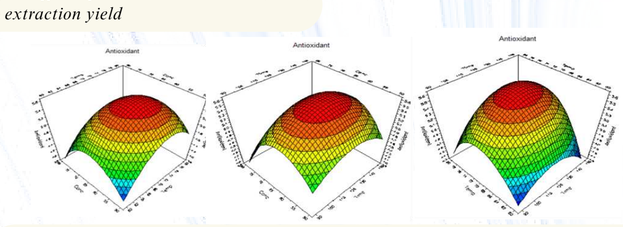


Figure 4: Response surface model illustrating the effect of ethanol concentration, time, and temperature on antioxidant activity

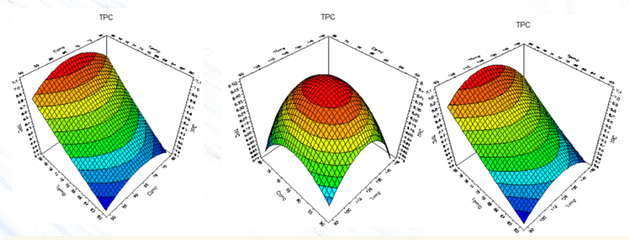


Figure 5: Response surface model illustrating the effect of ethanol concentration, time, and temperature on TPC

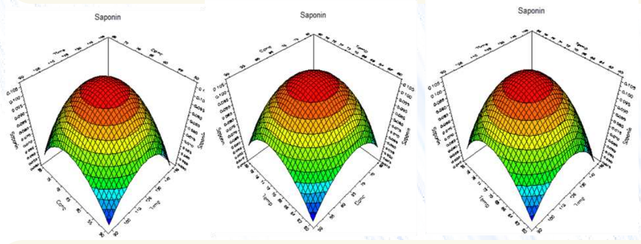


Figure 6: Response surface model illustrating the effect of ethanol concentration, time, and temperature on Saponin content

Table 3: Optimal parameters

Parameters	Reality content	Predicted content
TPC (mg GAE/g)	0.51 ± 0.01	0.51 ± 0.0005
AC (mg Vitamin C/g)	1.54 ± 0.08	1.54 ± 0.0002
TSC (mg OA/g)	8.25 ± 0.001	8.26 ± 0.0001
TCC (mg/g)	0.11 ± 0.0001	0.11 ± 0.0002
EY (%)	21.48	21.53

CONCLUSION

This study successfully optimized the extraction process of bioactive compounds from Gynostemma pentaphyllum using Response Surface Methodology (RSM), determining that factors such as ethanol concentration, time, and temperature significantly influence the extraction efficiency and the content of bioactive compounds including polyphenol, saponin, chlorophyll, and antioxidant activity. The optimal conditions achieved were an ethanol concentration of 80%, an extraction time of 115 minutes, and a temperature of 80°C, yielding the following values: polyphenol (0.51 ± 0.01 mg GAE/g dry sample), saponin (8.26 ± 0.001 mg OA/g dry sample), chlorophyll (0.11 ± 0.0001 mg/ml), antioxidant activity (1.54 ± 0.08 mg Vitamin C/g dry sample), and extraction yield (21.53%). The optimized model was validated with experimental results showing no significant difference compared to the predicted values ($p > 0.05$), confirming the reliability and suitability of the study. This result provides a scientific basis for applying the extraction process in industrial production to effectively exploit the bioactive compounds of Gynostemma pentaphyllum for the food, pharmaceutical, and medical fields, contributing to enhancing the utilization value of the medicinal plant and developing natural health-supporting products.

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