Optimizing Extraction of Stevioside and Rebaudioside A: Comparison of Thermal and Non-Thermal Processing Techniques

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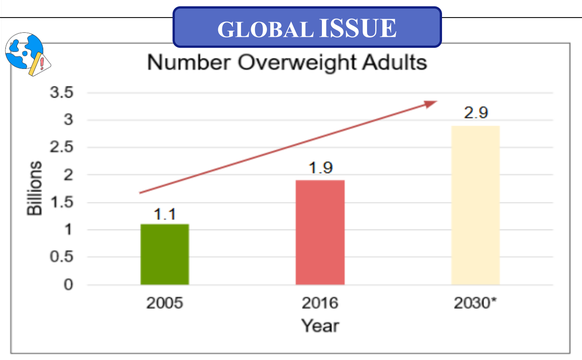
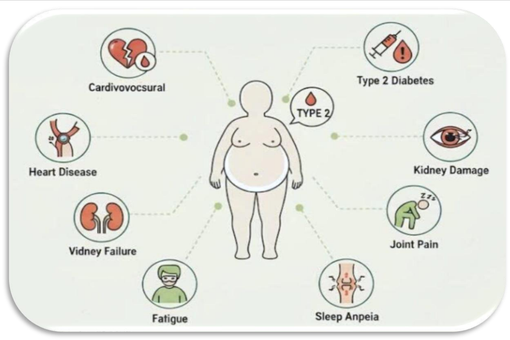
Introduction

GLOBAL ISSUE

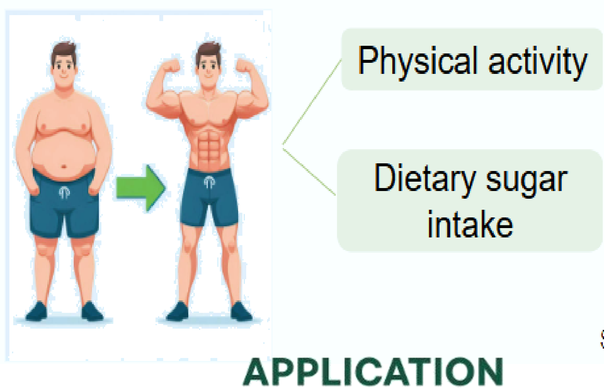


The illustration of an exponential rise in global obesity. (Islam et al., 2024)

SIDE EFFECTS

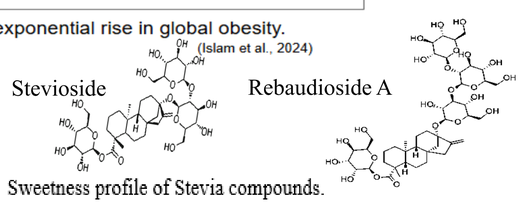


SOLUTION



RECOMMENDED

Stevia Sugar



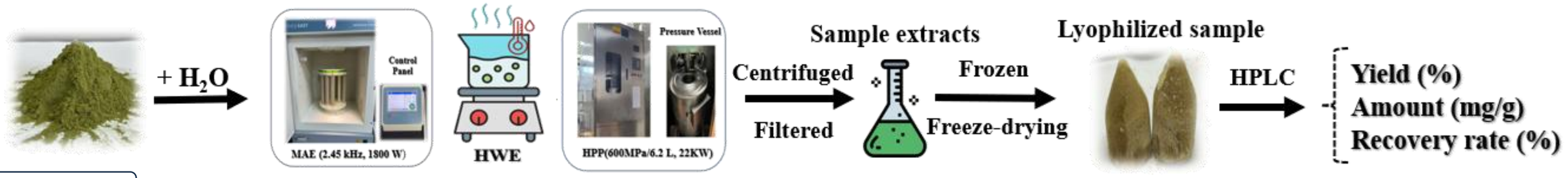
Sweetness profile of Stevia compounds.

Compound	Content in leaf	Sweetness (vs. sugar)	Taste profile
Stevioside (Stv)	4–20%	150–300×	Slightly bitter
Rebaudioside A (RA)	1–3%	200–400×	No bitterness

- High percentage of phytochemicals
- Good source of vitamins and minerals
- Essential amino acids and fatty acids

APPLICATION

Study Design



Results

Table 1. Validation and monitoring test for steviol glycosides.

Parameter	Stevioside	Rebaudioside A
Linear Regression	y=2E+06x+5227.4	y=2E+06x+29797
Coefficient of Determination (R^2)	0.9993	0.9999
Limit of detection	0.005	0.002
Limit of quantitation	0.016	0.005

LOD: Limit of detection. Signal-to-noise (S/N)=3

LOQ: Limit of quantitation. Signal-to-noise (S/N)=10

Table 2. The precision validation of stevioside and rebaudioside A.

Concentration (mg/mL)	Relative standard deviation (RSD, %)			
	Intra-day precision		Inter-day precision	
	Stevioside	Rebaudioside A	Stevioside	Rebaudioside A
0.25	1.57	1.04	1.14	1.00
0.125	1.17	1.75	1.58	1.44
0.01	1.06	2.10	1.77	1.13

Data represent the results of three independent experiments (n = 3).

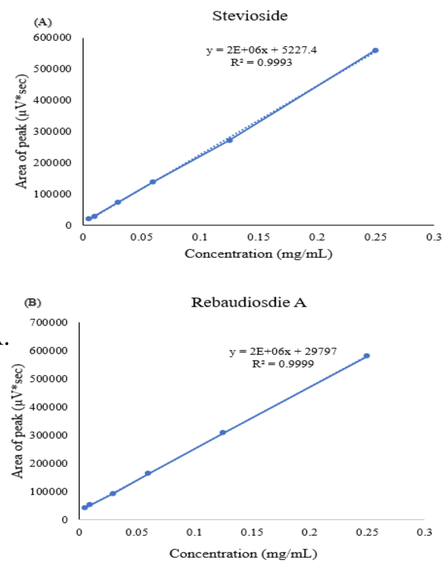


Figure 1. Calibration curves of stevioside (A) and rebaudioside A (B) standards at various concentrations.

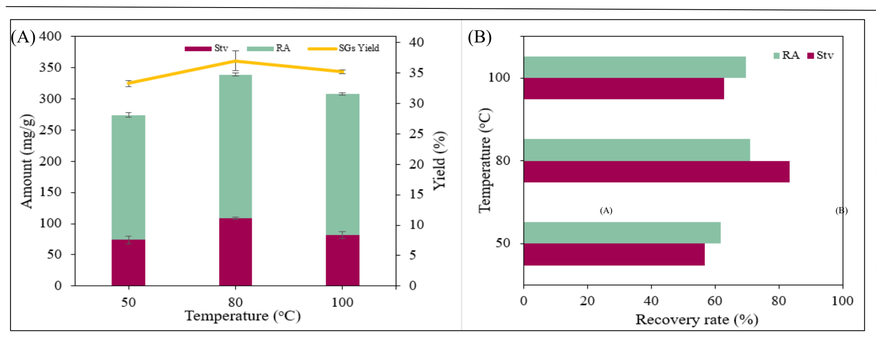


Figure 4. Yield of steviol glycosides (SGs) and amount in dried leaves (A), and recovery rate of stevioside (Stv) and rebaudioside A (RA) (B) obtained by microwave-assisted extraction (MAE) at varying temperatures.

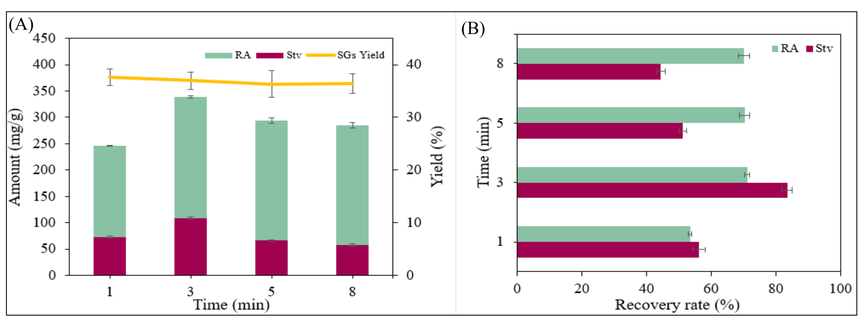


Figure 5. Yield of steviol glycosides (SGs) and amount in dried leaves (A), and recovery rate of stevioside (Stv) and rebaudioside A (RA) (B) obtained by high-pressure-assisted extraction (HPAE) at different extraction times.

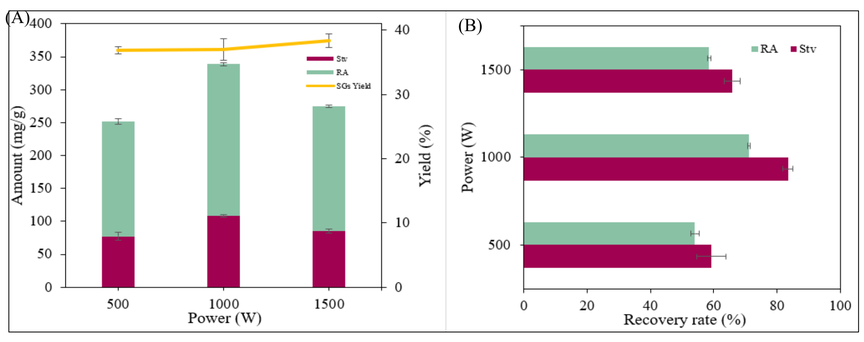
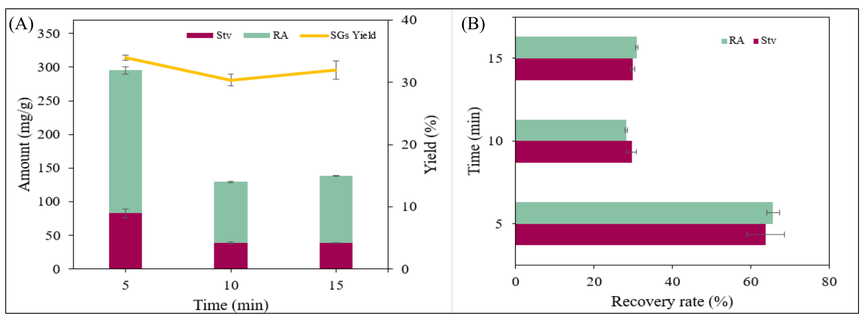


Figure 6. Yield of steviol glycosides (SGs) and amount in dried leaves (A), and recovery rate of stevioside (Stv) and rebaudioside A (RA) (B) obtained by microwave-assisted extraction (MAE) at differe power ranges.

Figure 2. Yield of steviol glycosides (SGs) and amount in dried leaves (A), and recovery rate of stevioside (Stv) and rebaudioside A (RA) (B) obtained by high-pressure-assisted extraction (HPAE) at different extraction times.



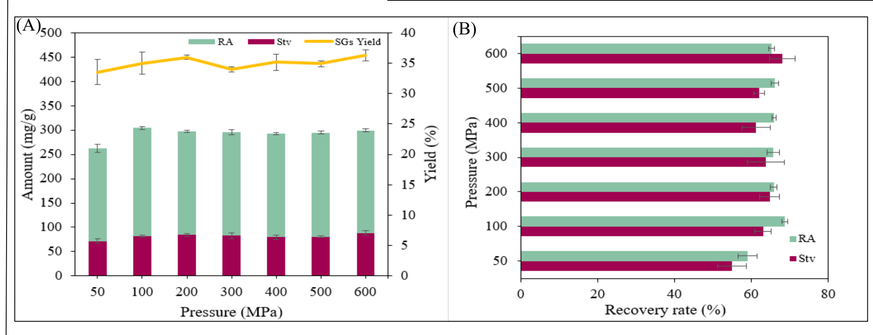
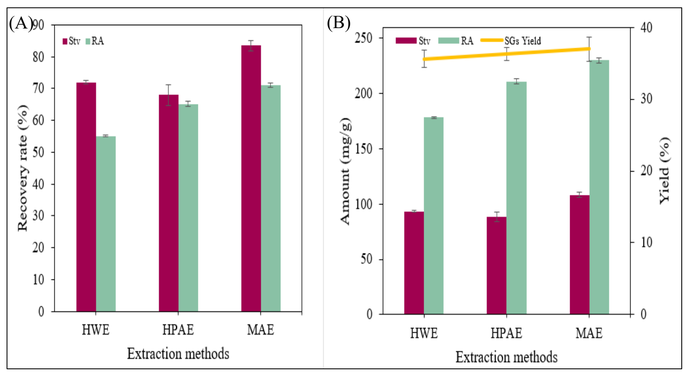


Figure 3. Yield of steviol glycosides (SGs) and amount in dried leaves (A), and recovery rate of stevioside (Stv) and rebaudioside A (RA) (B) obtained by high-pressure-assisted extraction (HPAE) at different pressure ranges.

Figure 7. Comparison of steviol glycosides (SGs) yield, amount (A), and recovery rates (B) of stevioside (Stv) and rebaudioside A (RA) obtained by hot water extraction (HWE), microwave-assisted extraction (MAE), and high-pressure-assisted extraction (HPAE) under optimal conditions.

*HWE operated at 60 min, 100 °C; HPAE operated at 5 min, 600 MPa; MAE operated at 3 min, 80 °C, 1000 W.



Disscusion

This study compared the efficiency of three extraction methods recovering Stv and RA from Stevia leaves, including MAE, HPAE, and HWE.

MAE performed optimally at 3 minutes, 80 °C, 1000 W, maximising yield and sweetener recovery while minimising thermal degradation. Rapid internal heating and cell wall rupture enhanced solvent penetration and mass transfer, especially for stevioside, which showed superior recovery in dried leaf extracts.

HPAE conducted at 600 MPa for 5 minutes was identified as optimal, enhancing steviol glycoside yield and stevioside content while maintaining sweetener stability. The applied pressure promoted molecular diffusion and solvent penetration, helping prevent degradation and solubility limitations associated with longer extraction times.

Both MAE (36.96%) and HPAE (36.28%) achieved slightly higher overall yield than HWE (35.59%). MAE (1000 W, 3 min, 80 °C) resulted in the highest recovery rate for Stv (83.48%) and RA (71.12%), while HPAE (600 MPa, 5 min) demonstrated balanced recovery of both compounds (67.96% for Stv and 65.22% for RA). Although HWE required a longer extraction time (60 min at 100 °C), it achieved considerable yields.

In conclusion, MAE showed the most efficient in terms of recovery, whereas HPAE emerged as the most promising non-thermal technique, combining high efficiency with preservation of sweetening compounds. These findings highlight the potential of novel extraction strategies to produce sustainable, health-promoting natural sweeteners for food applications.

Acknowlegdement

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