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Experimental and modelling studies of cinnamaldehyde extraction from cinnamon species by steam distillation

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ABSTRACT

Cinnamaldehyde is the main compound in Cinnamon species. This bio active compound has multi functional medicinal properties such as anti-pyretic, astringent, antibacterial and Cytotoxic effect. The objectives of this work were extraction of Cinnamaldehyde from Cinnamon species and to develop a modelling equation to quantitatively describe the extraction phenomena. The extraction was carried out by employing various organic solvents using Steam Distillation method for 90,000 seconds. Methanol was found to be the best solvent for the extraction of Cinnamaldehyde from Cinnamon species. Steam distillation was carried out using methanol at different extraction times to verify the mathematical model proposed in this work. The final form of the proposed models were $E_s = 1.44 (1 - e^{-0.01655t})$ for Cinnamaldehyde where Es = yield extract (grams of Cinnamaldehyde per gram of dried sample) and t = extraction time (min) and $E_s = 0.4 (1 - e^{-0.0224t})$ for Total phenolic content where Es = yield extract (mg of Total phenolic content per gram of dried sample) and t = extraction time (min). The model showed good agreement with the experimental data by generating Average absolute relative deviation (AARD) of about 0.8217 ± 50.738% for Cinnamaldehyde and 0.2748 ± 25.11% for Total phenolic content.

KEYWORDS

Cinnamon;
Cinnamaldehyde;
Total phenolic content;
Solvent extraction;
Modelling equation;
Steam distillation.

INTRODUCTION

Nature has been a source of medicinal agents. Extraction of bioactive compounds from medicinal plants has been permitted the demonstration of their physiological activity by medical researcher. Therefore there is need to search for plants with medicinally valuable and excellent extracts produced from widely varying substances. Cinnamon is a spice obtained from the inner bark of several trees from the genus Cinnamomum that is used in both sweet and savoury foods which is originated from Sri Lanka, East and West India, Mauritius, Burma, Indonesia and Vietnam[1]. with annual growth of (10-15 meters) 32.8-49.2 feet[2]. In Ayurvedic medicine Cinnamon oil is used for the rheumatism, aching joints and urinary problems. It contains

unique healthy and healing property due the presence of active components. The major and important compounds are Cinnamaldehyde (3-phenyl-acrolein, 65 to 75%), Eugenol (4-(1-propene-3-yl)-2-methoxy-phenol, 5 to 10%)[3]. Phenolic compounds are well known as radical scavengers, metal chelators, reducing agents, hydrogen donors, and singlet oxygen quenchers[4]. The molecular formula for Cinnamaldehyde is C_9H_8O and its molecular structure is shown in Figure 1. It is easily dissolved in methanol, ethanol, and ethyl acetate but partially soluble in water. The melting point of this compound is 246°C. The extraction of Cinnamaldehyde is done by Steam Distillation[5] and it also be extracted by HPLC [6] and gas chromatography. Cinnamaldehyde has various medicinal properties such as antipyretic, astringent, antimicrobial activity[7], anti - inflammatory activity[8], antibacterial and Cytotoxic effect[9-11].

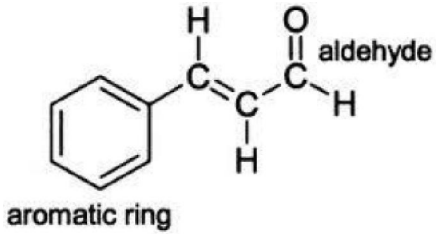

Figure 1 : Molecular structure of cinnamaldehyde

The objectives of this present work were to the extraction of Cinnamaldehyde and Total phenolic content from the Cinnamon species by using Steam Distillation and develop a mathematical model to describe the extraction procedure.

MATERIALS AND METHODS

Materials

The bark of the cinnamon was collected from the local market Visakhapatnam. Various organic solvents were purchased from Lotus Chemicals, Visakhapatnam. Clean the bark of the cinnamon and dried under sunlight for 1 day. The dried bark was powdered and used as a raw material and stored in the air tight container. It is finely grounded to 120 mesh size.

Solvent extraction using Steam Distillation apparatus

Prior to the solvent extraction study, 400ml of Distilled water in 500ml 3 vents round bottom flask. 8 grams of cinnamon bark powder was placed in a 250ml one vent round bottom flask. It was joining with a condenser and the inlet and outlet of the condenser was connecting with the tubes for water circulation. Add an amount of 200ml of 80% Methanol to the one vent round bottom flask containing cinnamon powder was kept for one day soaking. Join the two round bottom flasks with a pipe. Three vents round bottom flask was kept in a heating mantle and set the temperature around 80°C. The extraction was carried out for 9,000seconds in a steam distillation system and collects the distillate from the condenser. The entire system was shown in Figure 2. Solvent-Solvent extraction was done by hexane as solvent along with distillate in 1:1 ratio. After 2hrs of solvent extraction with hexane, two phases were separated, collect 1ml sample from extract phase and raffinate phase. Add 0.5ml FD reagent and 1ml Na_2CO_3. Make up this solution up to 10ml with distilled water. After 30min read the absorbance at 700nm. Steam distillation method was conducted using Methanolic extract at different extraction times to verify mathematical model proposed in this work.

Figure 2 : Steam distillation apparatus

Modelling of extraction of cinnamaldehyde using Steam distillation apparatus

In order to describe the Cinnamaldehyde transfer from Cinnamon powder to the bulk of the solvent the following hypothesis were used. The mass transfer coefficient is constant. The solvent in the extractor is perfectly mixed, while the transfer resistance in the liquid phase is negligible and the Cinnamaldehyde concentration in the solvent depends only on time. The transfer of the Cinnamaldehyde was a diffusion phenomenon and

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independent of time. The final form of the modelling equation[12] was obtained from the extraction of Cinnamaldehyde by using Steam Distillation.

$E_s = B (1 - e^{-Dt})$

Where, Es = grams of Cinnamaldehyde per gram of dried sample (g/g); t = extraction time (min) and B & D = equation constants.

RESULTS AND DISCUSSIONS

In comparison to non-polar solvents, polar solvents could extract Cinnamaldehyde at higher yield except water, where hydrolysis and thermal degradation might occur. Methanol was found to be the best solvent for the extraction of Cinnamaldehyde. The highest amount of Cinnamaldehyde extracted from 80% methanol concentration. The final form of the proposed model equation for Cinnamaldehyde was $E_s = 1.44 (1 - e^{-0.01655t})$ where Es = yield extract (grams of Cinnamaldehyde per gram of dried sample) and *t* = extraction time (min). The model showed good agreement with the experimental data by generating Average absolute relative deviation (AARD) of about 0.8217 ± 50.738% grams of Cinnamaldehyde per 1 gram of dried sample. For total phenolic content the final form was $E_s = 10.4 (1 - e^{-0.0224t})$ where Es =

TABLE 1: Effect of extraction yield with extraction time for cinnamaldehyde (CA)

Sr. No	Time (min)	Yield extract (gram of CA/ gram of dried sample)
1	10	0.13
2	20	0.13
3	30	0.1968
4	40	0.2625
5	50	0.3543
6	60	0.525
7	70	0.656
8	80	0.735
9	90	0.8137
10	100	0.9843
11	110	1.063
12	120	1.14
13	130	1.3125
14	135	1.4312
15	140	1.4437
16	145	1.4262
17	150	1.365

TABLE 2 : Effect of extraction yield with extraction time for total phenolic content (TPC)

Sr. No	Time (min)	Yield extract (mg of TPC/ gram of dried sample)
1	10	0.135
2	20	0.135
3	30	0.150
4	40	0.1625
5	50	0.175
6	60	0.2125
7	70	0.2375
8	80	0.2625
9	90	0.275
10	100	0.3125
11	110	0.325
12	120	0.3375
13	130	0.375
14	135	0.395
15	140	0.400
16	145	0.390
17	150	0.3875

Figure 3: Methanolic extract before Steam distillation

Figure 4: Methanolic extract after Steam distillation

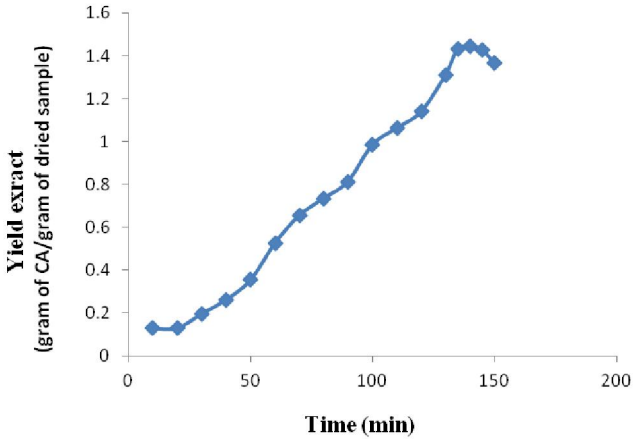

Figure 5: Effect of extraction yield with extraction time for cinnamaldehyde (CA)

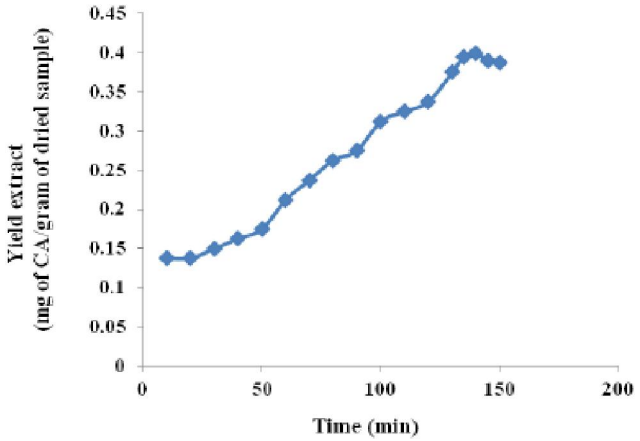

Figure 6: Effect of extraction yield with extraction time for total phenolic content (TPC)

yield extract (mg of Total phenolic content per gram of dried sample) and *t* = extraction time (min) and the Average absolute relative deviation (AARD) was 0.2748 ± 25.11% grams of Total phenolic content per 1 gram of dried sample. The results were showed in TABLE 1 and 2 and Figures 3, 4, 5 and 6.

CONCLUSION

Methanol was found to be the best solvent for the extraction of Cinnamaldehyde from Cinnamon species by Steam distillation. Among the different concentrations, 80% methanol shows highest yield. The final form of the proposed models were $E_s = 1.44 (1 - e^{-0.01655t})$ for Cinnamaldehyde where *Es* = yield extract (grams of Cinnamaldehyde per gram of dried sample) and *t* = extraction time (min) and $E_s = 0.4 (1 - e^{-0.0224t})$ for Total phenolic content where *Es* = yield extract (mg of Total phenolic content per gram of dried sample) and *t* = extraction time (min). The model showed good agreement with the experimental data by generating AARD of about 0.8217 ± 50.738% for Cinnamaldehyde and 0.2748 ± 25.11% for Total phenolic content.

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