CHAPTER-6

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

General:

The aim of the present study was to recover naringin and pectin from fresh, dropped, and dry kinnow peels using indigenous food grade adsorbent resins PA-500 and PA-800 for their valorization and value addition. A process technology for recovery of naringin and pectin from kinnow peels was developed. In this process, naringin was adsorbed from kinnow peel boiled water followed by desorbed with low cost eluent (ethanol). Ethanol-naringin solution was passed through membrane filter, and the filtrate was evaporated to obtain naringin. The naringin obtained was of high purity and yield. The pectin could also be precipitated from outgoing solution of naringin adsorption column as a by-product.

Naringin adsorption-desorption studies system 1 to 8

A. Adsorption studies

Equilibrium studies

The equilibrium behaviour of adsorption of naringin on the resins PA-500 and PA-800 from KPBW obtained from the three types (fresh, dropped, and dry) of peels also on the regenerated reins PA-500 and PA-800 from fresh peels, i.e., all the systems (1 to 8) could be described satisfactorily by Langmuir adsorption isotherm.

Studies with regenerated resin system 7 and 8

It may be noted desorption with ethanol could not completely remove naringin. After desorption with ethanol 1N NaOH warm (about $50^{o}C$) solution was passed through resin to regenerate it. The regenerated resin picked 85-90% naringin as compared to that fresh resin from same KPBW (obtained from fresh peels).

1. The naringin picked up from KPBW at a concentration 0.600 kg/m^3, by one kg dry resin in different systems is

System	1	2	3	4	5	6	7	8
	0.0663	0.0857	0.0913	0.1148	0.0606	0.0702	0.0521	0.0601

2. To summarize the equilibrium observation, the amounts of naringin picked up by the adsorbent q_e for different systems are in the order

Dropped peels with PA-800 (system 4) > Dropped peels with PA-500 (system 3) > Fresh peels with PA-800 (system 2) > Dry peels with PA-800 (system 6) > Fresh peels with PA 500 (system 1) > Dry peels with PA-500 (system 5) > Fresh peels with regenerated resin PA-800 (system 8) > Fresh peels with regenerated resin PA-500 (system 7)

Kinetic studies:

1. Most of the adsorption of naringin takes place in first 21600 (s).
2. The kinetic data for adsorption of naringin for all the systems studied could be correlated satisfactorily in terms of modified adsorption shell model. This model takes into account both macropore and micropore resistances in adsorption. The model predicts slightly lower take up of naringin than the experimental values during initial period of adsorption process.

Fixed bed column studies:

1. The breakthrough curves were determined at various flow rates and bed heights at room temperature. The obtained results showed that the adsorption of naringin was strongly dependent on the bed height and flow rate. Height of the mass transfer zone is the minimum for system 4 and amount of naringin adsorbed by the resin is maximum for system 4.

2. For treating 10000 ml of KPBW to adsorb the naringin from it about 150 g (FPD) resin PA-800 is required in 14 mm ID glass column with an outgoing flow rate of 2 ml/min (3.3×10^{-8} m^3s^{-1}).

Resin PA-800 performs better than PA-500 in equilibrium, kinetic and column studies.

B. Desorption studies

Equilibrium studies

1. The desorption equilibrium curves show that the desorption is favorable with ethanol but does not approach completion.
2. The desorption equilibrium experimental data could be be decsribed satisfactorly by Freundlich isotherm.

Kinetic studies:

1. More than 90% desorption takes place in 11000 (s), and kinetics could be modeled by Boyd's diffusivity model equation.
2. The Boyd's effective pore diffusivity for desorption of naringin into ethanol was found in the range $10\text{-}13 \times 10^{-13}$ m^2s^{-1}.

Column studies:

1. About 2000 ml of ethanol is required to desorb the naringin from about 120 g (FPD) resin PA-800 saturated with naringin obtained in adsorption column studies by passing KPBW through it in 14 mm ID glass column with an outgoing flow rate of 2 ml/min (3.3×10^{-8} m^3s^{-1}).

Recovery of naringin:

The recovery and purity of naringin is in the range of 45-55% and 88-92% respectively. Though the recovery is lesser than that obtained by using more sophisticated processes such as ultrasonic or SC-CO_2 extraction, however, due to high purity of the product obtained, the simple adsorption method studied in the present work may be preferred due to lesser initial costs involved than that in these processes.

Recovery of pectin:

Recovery of pectin is in the range of 51-63.0%. The pectin obtined in the studies had 60-72.5% anhydrouronic acid, 45-58%, degree of esterification (DE) and 6-8% methoxyl content. The obtained pectin is a high-methoxyl pectin (HMP) and high ester pectin.

Summary of products obtained from 1 kg peel:

The naringin and pectin obtained in this process from 1 kg of kinnow peels (wet basis) are

S.No	Type of peel	g Naringin/kg of peel		g Pectin/kg of peel	
		PA-500	PA-800	PA-500	PA-800
1	Fresh	3.0	3.1	1.1	1.10
2	Dropped	3.7	3.9	0.6	0.66
3	Dry	1.8	2.0	0.7	0.91

The present study is the first of its kind for recovery of both naringin and pectin from kinnow peels. By the recovery of naringin and pectin from kinnow peels, it may solve the environmental waste problems as well as add value to waste of citrus fruit and benefit kinnow growers and country as well. The process described in the thesis can be used for scaling up of the process to a pilot scale or commercial level thereby making the process more cost effective.

6.2. Recommendations

1. Pilot plant studies for recovery of naringin from kinnow peels is needed to be carried out to establish the commercial viability of this process in all probability. Such studies would be carried out in a fixed bed operation. Before commercialization it will be essential to establish

technical feasibility of the process in a pilot plant demonstration unit. Such a unit needs to be designed and fabricated.

2. Studies for recovery of essential oils during KPBW preparation for fresh peels are required.
3. The studies for recovery of naringin from peels of other citrus fruits like Coorg mandarin, Nagpur mandarin are required. So that same technology with a little modification may be used in the same processing plant.
4. The use of peel residue, after naringin and pectin extraction should be studied. It may be good source of fiber, protein etc.
5. Pectin precipitation parameters should be optimized.
6. Drying studies should be carried out so that fresh peels could be stored and used in off season.

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