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Design and development of pectin extraction unit for jackfruit waste

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Abstract
Jackfruit (*Artocarpus heterophyllus*) is a fruit crop widely distributed in India. About 60% of whole jackfruit is non-edible. A non-edible portion contains the outer prickly rind (peel), non- edible perianth (inner perigones), and central core. Waste jackfruit peel is presently not being utilized for any value-added process because of limited research activities focusing on the possible conversion of this waste peel to other valuable products. But, the outer peel of jackfruit is mostly fibrous and rich in pectin and calcium. To utilize jackfruit waste, pectin extraction unit was developed. The developed unit was capable to handle 1kg of jackfruit peel powder having heating and filtration tanks with precise temperature control. At temperature 70, 80 and 90 °C the developed pectin extraction unit yields 6.98, 11.39 and 7.81% of pectin powder respectively from 1 kg peel powder for extraction period of 2 hour.

Keywords: Jackfruit (*Artocarpus heterophyllus*), extraction unit, waste peel

1. Introduction

Jackfruit (*Artocarpus heterophyllus*) is a fruit crop widely distributed in India and is fast becoming prevalent among the length and breadth of the world. India is the second largest producer of jackfruit in the global scenario and is believed to be the motherland of jackfruit (Nandu Lal *et al*. 2020) [11]. Jackfruit is cultivated throughout India, Burma, Ceylon, Malaysia, Southern China, West Indies, limited area of Queensland (Australia) and Mauritius (Ahmmed *et al*. 2017) [1]. The production of jackfruit in India is 1945960 metric tonnes from 188340 ha (Anonymous1, 2021) [3]. The coastal warm and humid climate of the Konkan region is favourable for jackfruit cultivation (Gawankar *et al*. 2021) [7]. In Maharashtra jackfruit production is 7200 metric tonnes from 320 ha area (Anonymous1, 2021) [3]. About 60% of whole jackfruit is non-edible. A non-edible portion contains the outer prickly rind (peel), non-edible perianth (inner perigones), and central core (Subburamu *et al*. 1992) [14]. Waste jackfruit peel is presently not being utilized for any value-added process because of limited research activities focusing on the possible conversion of this waste peel to other valuable products. But, the outer peel of jackfruit is mostly fibrous and rich in pectin and calcium. Pectin is a natural product found in the cell wall of all higher plants. Pectin is a polymer of galacturonic acid and with that, an acidic polysaccharide part of the acid is present as the methyl ester. Pectin is a hydrocolloid that keeps a large amount of water and creates thickening and gelling properties Pectin can be described as a natural component of all edible plant material and is available in the plant cell wall and in the layer between the cells named middle lamella. It gives firmness to the plants and affects their growth and water storage. (Kumar *et. al*. 2018) [9]. Pectin is mostly used in commercial and home production, of jams and jellies as a thickening and gelling agent (Alamineh, 2018) [2]. The global pectin market was valued at 1204.25 million USD in 2021 and is likely to grow with a CAGR of 2.54% from 2021 to 2027, based on the researcher newly published report (Anonymous2, 2022). If a small fruit processor uses the fruit peel waste after processing to extract value-added products such as pectin, essential oil, and lignin then they can earn some money from the waste material generated in their plant. About 3.15 tonnes of processing waste generated per acre from jackfruit out of which 2.27, 0.63 and 0.25 tonnes of waste generated from rind, seed and latex respectively (Kalse and Swamy 2022) [8]. So, in Maharashtra from 320 ha about 1794.95, 498.15 and 197.68 tonnes of waste generated in the form of rind, seed and latex respectively on dry basis. This gives scope to design and development of pectin extraction unit for jackfruit waste and characterizes pectin.

2. Materials and Method

Mature jackfruits were purchased from local market of Dapoli, District Ratnagiri, Maharashtra. Peel wastes of jackfruit were used to extract pectin using pectin extraction unit. Hydrochloric acid and ethanol required for the research used from laboratory stock.

2.1 Development of Pectin Extraction Unit

Pectin extraction unit were designed for extraction of pectin from jackfruit waste. The schematic view of pectin extraction unit was shown in fig. 1. The pectin extraction unit was fabricated in workshop of Bharat Farmtech Kolhapur during period 2021-22. Raw materials such as M.S. angle, M.S. plate, S.S. metal sheet, S.S collar, ball bearings, gear motor, M.S. bush, agitator assembly, heater, temperature sensor, nut-bolts etc. were used to fabricate pectin extraction unit. The developed pectin extraction unit for jackfruit waste was shown in fig. 2.

Various engineering aspects were taken into account while developing the pectin extraction unit for jackfruit waste such as material selection, capacity of unit, speed of agitation, heating control, power of motor etc.

2.2 Design consideration for development of pectin extraction unit for jackfruit waste

Development work of pectin extraction unit for jackfruit waste was undertaken in a view of medium output capacity and able to extract pectin with minimum cost. Temperature, agitation speed, peel to water ratio and filtration were important parameter to achieve high pectin yield. Following points were considered for development of pectin extraction unit for jackfruit waste.

1. Speed of agitator of pectin extraction unit should be around 150 rpm.
2. In single batch 1kg of peel powder must be processed.
3. It should be safe and having low maintenance cost.
4. It should be low-cost unit.

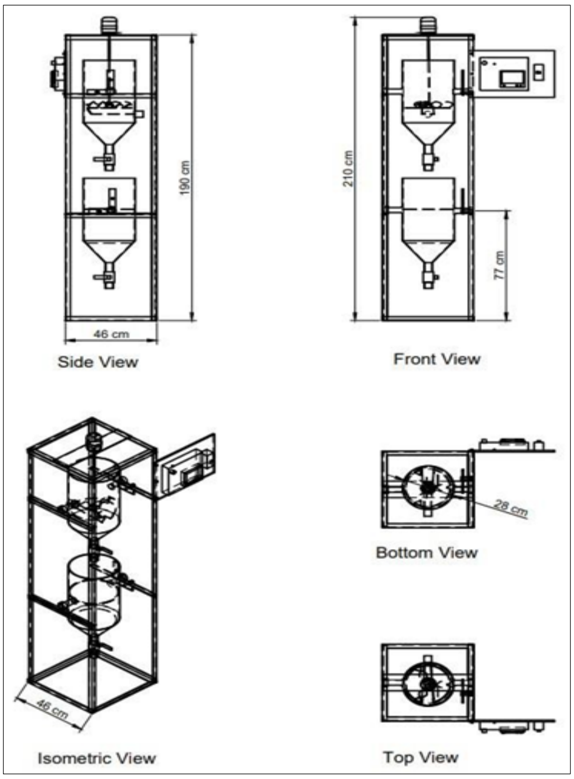

Fig 1: Schematic view of pectin extraction unit

2.2.1 Material selection for fabrication of pectin extraction unit

As the tanks are remain in direct contact with mixture of jackfruit peel powder and water and extracted pectin is food additive it is then necessary to use food grade stainless steel to fabricate tanks. As per (Saravacos and Kostaropoulos 2002) [12] food grade stainless steel S.S. 304 and 316 are two options available with great tensile strength. S.S. 316 was costlier than S.S. 304 so to make unit at low-cost S.S. 304 sheets of gauge 16 selected to fabricate both heating and filtration tanks. Its nominal composition is 18% chromium and 8% nickel. Also, S.S. 304 wires used to fabricate primary screen of filtration unit. Based on previous studies most of author used muslin cloth as a filter during pectin extraction process so secondary screen were made up from muslin cloth which can be easily removable for cleaning. To give good strength to unit M.S. angles were used to fabricate main frame.

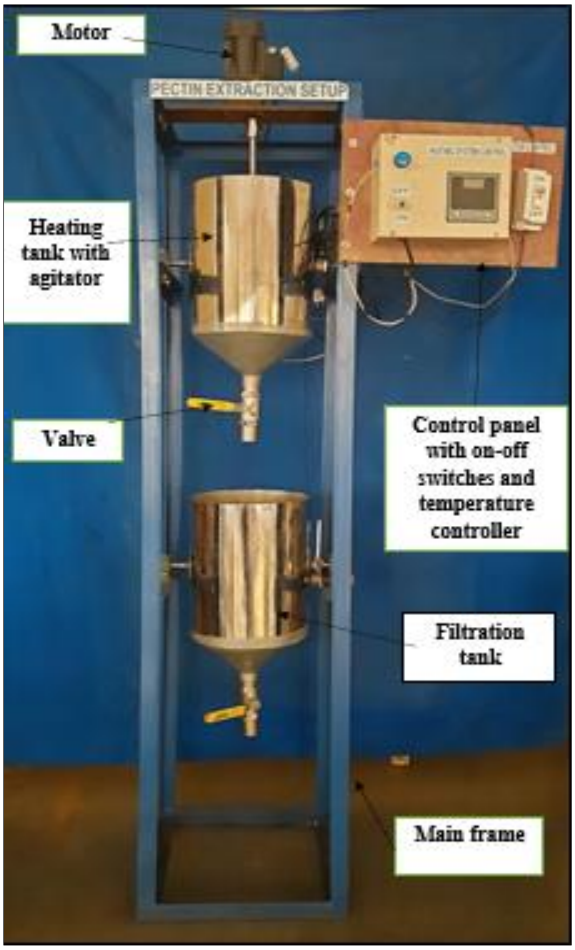

Fig 2: Developed Pectin Extraction Unit

2.2.2 Capacity of pectin extraction unit

Dimension of pectin extraction unit was taken by considering processing of 1kg of jackfruit peel powder.

$$Volume\ of\ tank\ required = Vw + Vp + Va \qquad (1)$$

Where,

Vw = Volume of water in mL,

Vp = Volume of 1Kg jackfruit peel powder in mL, and Va = Volume of 0.5N hydrochoric acid in mL

The dimensions of tank shown in fig. 1. On that basis tank can handle 24207.3 mL which is more than volume of tank required because some extra space is needed for heater and agitator and also additional space is useful to handle mixing flow pattern of liquid mixture. Both tanks were made up of same volume because they have to handle almost same amount of mixture.

2.2.3 Agitation motor and rpm

The rpm of agitation was selected to be 150 rpm based on study of (Vasco-Correa and Zapata 2017) [16] as per their study adequate Galactouronic acid (GalA) solubilization could be obtained at any point between 120 and 180 rpm. Value of GalA is very important because it indicates purity of pectin.
Power requirement for agitator motor was calculated by following equation as used by (Freitas *et al*. 2020) [6],

$$Np = P/\rho \times N\,3 \times D\,5 \quad (2)$$

Where,
Np is power number,
P is required power in watt,
ρ is the specific gravity of fluid in kg/m3, N is speed of agitator in rps, and
D is the diameter of agitator in m.

2.3 Performance evaluation of developed pectin extraction unit for jackfruit waste

Performance evaluation of developed pectin extraction unit for jackfruit waste was carried at two different levels of temperature. Performance of developed pectin extraction unit for jackfruit waste was compared with previous laboratory scale studies on pectin extraction from jackfruit peel waste. Performance evaluation was done on the basis of the yield of pectin from the jackfruit waste.

2.3.1 Extraction of pectin

1 kg of the ground jackfruit peel was weighed and poured in pectin extraction unit in which already 10 litre of distilled water. Extraction of pectin carried out with temperature 70, 80 and 90 °C for 1.5, 2 and 2.5 hr. pH were adjusted to 1.9 by using 0.5N hydrochloric acid. The hot acid extracts were filtered through filtration tank by using primary and secondary filter. The filtrates were cooled to room temperature. Two volumes of 95% ethanol were added to allow pectin precipitation. Finally, the precipitate was kept for drying at 50 ºC for 16 hours in a hot air oven and the ground powder was kept in airtight plastic bag as reported by (Sundarraj *et al*. 2017) [15].

2.3.2 Yield of pectin

Pectin yield was calculated by the equation used by (Sundarraj *et al*. 2017) [15] which is as follows,

$$y_{pec}(\%) = 100 \times \frac{p}{B_i} \quad (3)$$

Where,
ypec (%) is the extracted jackfruit peel pectin yield in percent (%),
p is the amount of extracted jackfruit pectin in gram (g), Bi is the amount of initial jackfruit peel powder (g).

At given conditions all experiments were carried triplicate and average value was used to determine pectin yield at that given condition.

2.3.3 Identification of Pectin

The procedures from Food Chemical Codex were used to identify and characterize the extracted pectin which was used by (Cristy *et al*. 2014) [5]. 1 g of pectin powder weighted and transfer to the beaker and added 100 mL of water and mixed well. Later 100 mL ethyl alcohol was added. Gelatinous precipitate confirms pectin.

4. Results and Discussion

4.1 Comparison of different temperature on pectin yield extracted by pectin extraction unit

The yield of pectin extracted from the jackfruit peel varied from 5.77 to 11.39% of the dry weight of peel depending on extraction temperature as shown in Figure 3. The highest yield of pectin obtained at 80 °C which is 11.39% for 2 hr of extraction time. Study found that extraction time also affects the yield of pectin. At extraction time 1.5 hr the yield of pectin was lower than extraction time of 2 and 2.5 hr. Highest yield was found at extraction period of 2 hr for extraction temperature of 70, 80 and 90 °C. Pectin yield increases from extraction time of 1.5 hr to 2 hr and gradually decreases at 2.5 hr this might be because of up-to certain limit extraction time allows temperature to sufficiently breaks the cell wall and protopectin to be hydrolysed by acids to get pectin but prolonged extraction may degrade the pectin as found by Ahmmed *et al*. (2017) [1].

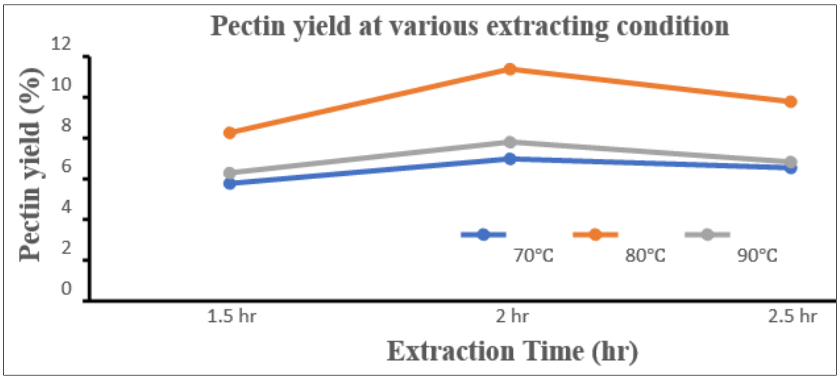

Fig 3: Yield of pectin at various extracting temperature and time

The highest yield of pectin from pectin extraction unit was 11.39% at 80 °C temperature for 2 hr extraction time whereas at same condition Ahmmed *et al*. (2017) [1] found 14% yield of jackfruit peel pectin. Yield might be less because the variety, and the peels state can affect the pectin yield and it depends on the type of raw material and methods of preliminary treatment as reported by Sahay *et al*. (2014) [13].

4.2 Identification of pectin
Based on the procedure given by Christy *et al*. (2014) [5] test was performed to identify the extracted product as a pectin. Results shows formation gel means extracted product was confirmed to be pectin.

Fig 4: Pectin confirmation test gel confirms pectin

Fig 5: Extracted pectin powder

4.3 Cost estimation
The development cost of pectin extraction unit was found to be Rs 68159/- Which included material cost Rs. 52430/- as well as the fabrication cost Rs. 15729/-.

Table 1: Cost of material required for fabrication

Sr. No.	Material	Specification	Quantity	Price
1	SS Metal Sheet	SS304	-	15900/-
2	MS Angle	40×40×5, 24 Feet		4450/-
3	MS Plate	120×10×450 20×5×150	1 2	1650/-
4	MS Bush	ID 17	4	800/-
5	SS Valve	1 Inch	2	2100/-
6	SS Collar	1 Inch	4	1650/-
7	Bearings	UCP 202	4	2400/-
8	Agitator Assembly	Shaft, Fan	-	1250/-
9	Gear Motor	188 Watt	1	11500/-
10	Heater	2000 Watt	1	1850/-
11	Temperature Sensor	-	1	1800/-
12	Control Panel	Display, Switches, MCB	1	5800/-
13	Electric Wiring	-	-	980/-
14	Nut, Bolt, Washer	-	-	200/-
Total material cost				52430/-
Fabrication cost				15729/-
Total cost of unit				68159/-

5. Conclusion
Developed pectin extraction unit successfully extracted pectin from jackfruit peel waste. Pectin yield greatly affected by extraction temperature. The highest yield of pectin from pectin extraction unit was 11.39% at 80 °C temperature for 2 hr extraction time at pH 1.9.

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