International Journal of Drug Development & Research
| April-June 2013 | Vol. 5 | Issue 2 | ISSN 0975-9344 |
Available online http://www.ijddr.in
Covered in Official Product of Elsevier, The Netherlands
SJR Impact Value 0.13 & H index 2

Full Length Research Manuscript

Evaluation of Pectin derived from Orange peel as a Pharmaceutical Excipient

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Abstract

The objective of the present work is extraction of pectin from waste of orange fruit peel and further characterization for useful alternative pharmaceutical excipient. The pectin was subjected to phytochemical and physicochemical characterization of its safety and suitability to use as binding and suspending agent. FT-IR spectroscopy, DSC studies were performed for drug, orange peel pectin powder, prepared tablet and suspension formulations. Aceclofenac tablets were prepared by wet granulation method containing mannitol as diluent; using 2.5, 5, 7.5 and 10 %w/w of orange peel pectin powder and 7.5 %w/w of PVP (reference) as binding agents in the tablet formulation. Aceclofenac suspensions were prepared with orange peel pectin powder at 0.5, 1, 1.5 and 2 %w/v as suspending agent and 1.5 %w/v of sodium CMC as reference suspending agent. Pharmaceutical properties of granules and tablets such as carr's index, Haunser's ratio and angle of repose and post compression parameters like friability, hardness, and disintegration time studies were determine and found satisfactory. The evaluation test of suspension like sedimentation volume, redispersibility, pH, degree of flocculation were found satisfactory. *In vitro* release studies shows that release rate of drug is decreased with increase in the orange peel pectin powder percentage in the formulation. Orange peel pectin powder showed good binding and suspending properties at 10 %w/w and 2 %w/v, respectively.

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Key words:
Aceclofenac, orange peel pectin powder, FTIR, DSC

***How to Cite this Paper*:**
M Ravindrakullai reddy, Kopparam Manjunath* "Evaluation of Pectin derived from Orange peel as a Pharmaceutical Excipient" Int. J. Drug Dev. & Res., April-June 2013, 5(2): 283-294.

Article History:----------
Date of Submission: 27-03-2013
Date of Acceptance: 07-04-2013
Conflict of Interest: NIL
Source of Support: NONE

INTRODUCTION

Mother Nature has gifted India with great variety of flora and fauna. For centuries man has made effective use of materials of natural origin in the medicinal and pharmaceutical field. Natural materials have advantages over synthetic materials because they are non toxic, less expensive, freely available, biodegradable and edible sources [1]. They are used as binding, thickening, emulsifying,

suspending, stabilizing agents in pharmaceutical industries and used as matrices for sustained release of drugs [2-3].

Pectin, a multifunctional constituent contained in the cell wall of terrestrial plants. Pectin is a non-starch linear polysaccharide consists of 1, 4 D-galacturonic acid [4]. Galacturonic acid of pectin may or may not be esterified with methanol or acetic acid, in which case percentage esterified groups are expressed as degree of methoxylation (DM) and degree of acetylation (DA) respectively. Low degree of methoxyl pectins (< 50 % esterified) form thermo reversible gels in the presence of calcium ions and at low pH (3 - 4.5) whereas high degree of methoxyl pectins (>50 % esterified) rapidly form thermally irreversible gels in the presence of sufficient (for example, 65 % by weight) sugars such as sucrose and at low pH (< 3.5)[5]. Pectins are mainly used as gelling agent and also act as thickener. In view of above interesting aspects, pectin still remains a promising excipient for oral drug delivery. In the present study, we have extracted pectin for orange peel and verified its potentials for using as binding and suspending agent in the aceclofenac tablet and suspension dosage forms.

MATERIALS AND METHODS

Materials

Aceclofenac is purchased from Yerrow Chem, Pvt. Ltd and orange peel pectin powder was extracted in the lab. Mannitol, sodium starch glycolate, magnesium stearate, talc, sodium CMC, methyl paraben, propyl paraben and vanillin flavor are of analytical grade.

Methods

Extraction of orange peel pectin powder

Ripped orange peel was obtained from local fruit shop. Peel was carefully washed and dried under shade for 24 h, further dried at 60 °C in a hot air oven. Dried fruit peel was cut into pieces and powdered by electric grater. Powdered peel was further passed from sieve No. 20. Peel powder, 200 g of was dissolved in 1 L of water and 1 g of citric acid was added to maintain acidic pH 2. This solution was subjected to reflux condensation at 70 ºC for 6 h to extract pectin. The extractor thimble was a whatman cellulose thimble with 33 mm internal and 80 mm external length. Hot acid extract was pressed in a cheese cloth bag and the concentrated juice was cooled to 4 ºC. Pectin was precipitated by ethanol: water (2:1 v/v) treatment followed by continuous stirring for 15 min and allowed to stand for 2 h. Pectin coagulate was filtered through cheese cloth, washed with 95 % alcohol and pressed. Pressed pectin was further dried to constant weight at 35 – 45 ºC. Hard pectin cake was ground and passed through sieve No.60, stored in desiccators for further use [6].

Preliminary phytochemical screening of orange peel pectin powder

The phytochemical properties such as presence of alkaloids, carbohydrate, glycosides, tannins, proteins and amino acids were determined [7] as shown in Table 1.

Physicochemical characterization of orange peel pectin powder

The physico chemical characterization of orange peel pectin powder such as solubility, pH, loss on drying, viscosity and ash values were determined as shown in Table 2.

FT-IR Studies

Pure drug aceclofenac, orange peel pectin powder, prepared tablet formulations and suspension formulation are studied for FT-IR spectra. Aceclofenac suspension formulation was filtered using Whatman filter paper and the residue was used for the FT-IR study [8].

Scanning Electron Microscopy

Extracted orange peel pectin powder is subjected for SEM studies to understand its surface morphological characters.

Differential Scanning Calorimetry

DSC studies were carried out for pure aceclofenac, orange peel pectin powder and tablet formulation F4 to find out any chemical interactions among them.

Preparation of Aceclofenac Tablets

Aceclofenac was used as model drug, wet granulation method was used for preparation of the aceclofenac tablets. Drug and excipients are passed through the sieve no.60 individually. Aceclofenac, orange peel pectin powder, mannitol and sodium starch glycolate were added and mixed uniformly. Distilled water in a sufficient quantity was added to form a wet mass and it was passed through the sieve no. 12. Distilled water was added as granulating fluid. The same procedure was followed to prepare the granules with different concentrations of orange peel pectin powder (2.5, 5, 7.5 and 10 %w/w) and 7.5 %w/w concentration of PVP as synthetic binding agent for comparison shown in Table 3. The prepared granules were subjected to evaluate pre compression parameters. Granules were lubricated with magnesium stearate, talc and were compressed into the tablets of 200 mg, using 10 station rotary tablet compression machine (Shakti Pharma Tech, Ahmadabad) [9].

Evaluation of Aceclofenac Granules

Angle of repose[15]

The angle of repose was calculated using the formula,

$$\theta = \tan^{-1}(h/r)$$

Where

θ = angle of repose

h = height of pile,

r = radius of the base of the pile.

Compressibility Index

Tapped bulk density and untapped bulk density was measured using measuring cylinder.

The compressibility index was calculated using formula:

$$\text{Percent compressibility index} = \frac{\text{Tapped bulk density} - \text{untapped bulk density}}{\text{Tapped bulk density}} \times 100$$

Evaluation of the Tablets[16]

Weight Variation Test

Randomly selected twenty tablets were weighed individually and together in a single pan balance. The average weight was noted and percentage deviation was calculated.

Hardness, Thickness

Six tablets were taken randomly and hardness was measured by the Monsanto hardness tester. Hardness was expressed in Kg/cm^2. The thickness and diameter of the tablet was measured using Vernier calipers.

Friability

Twenty tablets selected randomly from each batch were tested at a time. Tablets collective weight was determined before (W1 g) and after (W2 g) the test. The percentage friability was then calculated by formula,

$$\text{Percentage Friability} = \frac{W1 - W2}{W1} \times 100$$

Drug content

Five tablets were weighed individually and powdered collectively. The powder equivalent to average weight of tablets was weighed and drug was extracted in phosphate buffer pH 6.8, the drug content was determined spectrophotometrically. In case of suspension, 5 ml was subjected to extraction with phosphate buffer pH 6.8 and measured the absorbance after suitable dilution using a UV spectrophotometer at 274 nm.

Disintegration Test

Disintegration test was carried out according to I.P. method. Six tablets were placed in glass tubes of disintegration apparatus. Disintegration fluid temperature was maintained at 37 ± 2 °C and time required for disintegration was noted.

***In vitro* Dissolution Studies**

The dissolution of aceclofenac tablets & suspension was carried out using phosphate buffer pH 6.8 at 37 ± 1 °C & rotation speed of the paddle was maintained at 50 rpm for tablets and 25 rpm for suspension. Samples were withdrawn at every 10 min until 120 min in case of tablets, whereas in case of suspension samples were withdrawn at every 2 min until 24 min in case of suspensions. Dissolution media was replaced each time to maintain 900 ml volume constant. Samples were analyzed using UV Spectrophotometer at 274 nm. Similarly a marketed

tablet, Acenac also studied for dissolution studies for comparison purpose [10].

Preparation of Aceclofenac Suspension

Aceclofenac (1 g) and orange peel pectin powder (0.25 g) are triturated to get a fine powder, little quantity of distilled water was added and continued trituration. Methyl paraben, propyl paraben and vanillin are added in sufficient quantities and volume was made up to 50 ml using distilled water and stored in a well closed dispensing bottle (Table 4). Similarly aceclofenac suspensions were prepared with different concentrations of orange peel pectin powder (1, 1.5 and 2 %w/v). A reference aceclofenac suspension was prepared using 1.5 %w/v sodium CMC as synthetic suspending agent for comparison purpose [11].

Evaluation of Aceclofenac Suspension

pH Measurements

The pH measurements of the suspensions were done weekly for three weeks using a digital pH meter.

Sedimentation Volume [12]

Each suspension (50 ml) was placed in a 100 ml measuring cylinder and stored for 7 days at room temperature. The volume of the sediment at every hour for 7 hr and then every 24 hr for 7 days was noted. Marketed product IMOL was selected for comparison. The sedimentation volume of different suspensions was calculated by the equation

F = Vu /Vo;

Where

F is the sedimentation volume.

Vu is the ultimate volume of the sediment and

Vo is the original volume of the of suspension.

Redispersibility [13]

Fixed volume of each suspension (50 ml) was kept in stoppered dispense bottles which was stored at room temperature for 7 days. At regular interval, one bottle was taken and turned upside down until there was no sediment at bottom of the bottle and numbers of turns were noted.

Determination of Flow Rate

10 ml of suspension was taken in a pipette and time required to flow was noted to calculate flow rate of suspension.

Flow rate (η) = volume of pipette (ml) / flow time (min)

Viscosity

The viscosity (in poise) of the samples was determined at 25 °C using the Brookfield Synchroelectric viscometer; model LVF at 25 & 50 rpm (Spindle #2).Determinations were in triplicate.

Particle Size Analysis [14-15]

Particles size of prepared suspensions was measured by microscopic method. A slide of suspension was prepared and size of particles was measured using calibrated eye piece micrometer.

Degree of Flocculation

The degree of flocculation was determined using the equation

$$\beta = F/F_{\infty}$$

Where

F is ultimate sedimentation volume in flocculated suspension.

F_{∞} is ultimate sedimentation volume in deflocculated suspension.

Stability Studies

Stability studies of optimized formulations were done as per ICH guide-lines, by storing the tablets at 40 ± 2 °C / 75 ± 5 % RH for 3 months.

RESULTS AND DISCUSSION

Phytochemical characterization of orange peel pectin powder results revealed that orange peel pectin powder showed positive result with molish test, Fehling's test and Barford test. This indicates presence of carbohydrates and reducing sugar in the orange peel pectin powder. Negative results were shown for alkaloids, tannins, glycosides, proteins and amino acids.

As per physico chemical characterization orange peel pectin powder was soluble in water and insoluble in acetone and other organic solvents. pH of orange peel

pectin powder solution showed 6.36. Microbial studies reveal that there is no microbial growth after three days study. Total ash, water soluble ash and acid insoluble ash (%) was 6.25, 5.89 and 0.89, respectively.

FT-IR spectra for pure aceclofenac, orange peel pectin powder, optimized aceclofenac tablet formulation F4 & aceclofenac suspension formulation F9 are shown in the Figure 1. In the beginning aceclofenac suspension was used as it is for FT IR studies, which showed less intense absorption peaks for drug because of less concentration of drug in suspension. Therefore, suspension was subjected to filtration as mentioned in the methodology section and residue was used for studies. The characteristic absorption peak of pure aceclofenac was retained in the spectra of a tablet formulation and as suspension formulations. There is a no changes in the absorption peaks of drug in the final formulation was observed. Hence, there is no interaction of the drug with the orange peel pectin powder as well as other excipients used.

DSC thermogram of aceclofenac (Figure 2) shows sharp endothermic peak at 156.25 °C, this shows the crystalline nature of the aceclofenac sodium. Purified orange peel pectin powder thermogram showed that orange peel pectin powder is in amorphous nature. Endothermic peak of the aceclofenac is appear to be shifted to higher melting point 168 °C, in fact there is merging of aceclofenac peak and mannitol peak as shown in the thermograms of formulations. DSC studies revealed that there is no interaction of drug with excipients.

SEM photos of orange peel pectin powder shown in Figure 3A & 3B. The orange peel pectin powder particles are asymmetric and smooth surface observed. The size range of particles was from 50-200 µm approximately.

Angle of repose of granules found to be 26 to 29° indicates good flow of granules. Bulk density was found to be in the range of 0.54- 0.64 g/cc. Tapped density in the range of 0.59-0.64 g/cc. Carr's index was found to be 10.24-13.64. Haunser ratio was in the range of 1.09-1.13 shown in Table 5. These values are satisfactory for granules to be compressed.

Hardness of aceclofenac tablets were 3.05 - 5.89 kg/cm^2. Friability was found in the range of 0.42 - 0.91 %. Thickness was 2.21 – 3.17 mm shown in Table 6. Hence, tablets prepared with orange peel pectin powder as binding agent provided required properties to tablets.

Particle size of the all suspension formulations were range of 8 - 18 µm determined by microscopic method. Viscosity of the all formulations was found to be 13.26 - 29.69 cps at 25 & 50 rpm. Degree of flocculation was 1 - 1.23. Flow rate was 0.50 - 1.02 ml/min for different suspensions. Drug content of suspension formulations prepared with orange peel pectin powder was found to be in the range of 97.15 to 101.06 % shown in Table 7.

Sedimentation studies percentage sedimentation volume of aceclofenac suspensions was directly proportional to suspending agent concentration. However, in each suspension percentage sedimentation volume inversely proportional to time in days. In case of F6 formulation as the time increased from zero to 7 days the percentage sedimentation volume decreased from 100 to 64 [Table 8], (Figure 4). Whereas formulation F9 shows 98 % sedimentation volume. Hence, F9 was selected as an optimized formulation. Redispersibility and pH was found to be in the range of 1 - 3 turns and 5.28 - 6.82 [Table 9].

In vitro release studies of aceclofenac tablet showed that 97.52 % drug released within 60 minutes in case of formulation F1. Whereas formulation F2 released

99.55 % within 80 minutes, formulation F3 released 99.69 % within 100 minutes, whereas formulation F4 released 99.86 % within 120 minutes. As percentage of orange peel pectin powder increased in the formulation, more amount of time taken to release about 98 % of the drug from different tablet formulations. Formulation F5 prepared with synthetic binding agent PVP released the drug 99.22 % within 90 minutes; marketed product released 99.32% within 90 minutes of dissolution studies [Table 10], (Figure 5). Formulation F4, is optimized even through formulation F1, F2 & F3 released 98 % of the drug earlier to the formulation F4 because formulations F1, F2 & F3 did not posses enough hardness and did not pass for the friability test.

In vitro release studies of suspension showed that 97.34 % drug released within 16 minutes in case of formulation F6. Whereas formulation F7 released 97.12 % within 18 minutes, formulation F8 & F9 released 98.72 and 99.39 % within 22 and 24 minutes. As percentage of orange peel pectin powder increased in the formulation increase amount of time taken to release about 98 % of the drug from different suspension formulations, shown in the [Table 11], (Figure 6). Formulation F9 is optimized even though formulation F6, F7 & F8 released 98 % of the drug earlier to the formulation F9 because formulations F6, F7 & F8 did not show enough percentage sedimentation volume. Release kinetics of optimized tablet and suspension formulations was followed zero order kinetics and non fickian model.

The stability studies for optimized formulations were carried out at 40 ± 2 °C / 75 ± 5 % RH for 3 months. There was no significant change in the physical property and drug content during the study period.

CONCLUSION

The orange peel pectin powder exhibited good binding and suspending properties for the aceclofenac tablets and suspension. The increased concentration of pectin showed small retardation in drug release from tablet and suspension. Therefore, orange peel pectin powder can be used as a pharmaceutical excipient in tablets and suspension preparations. Orange peel pectin powder 10 %w/w and 2 %w/v were optimized as binding and suspending agents, respectively.

Table 1: Phyto chemical characterization of Orange peel pectin powder

S. No.	Name of the test carried out		Inference
1	Test for alkaloids	Mayers test	-
		Dragon draffs test	-
		Wagner test	-
		Hagers test	-
2	Test for carbohydrates	Molish test	+
		Fehlings test	+
		Benidicts test	+
3	Test for glycosides	Liebermann-Burchard's test	-
		Legals test	-
4	Test for mucilage	Ruthenium red test	-
5	Test for tannins	Ferric chloride test	-
		Lead acetate test	-
		Aqueous bromine test	-
6	Test for proteins and amino acids	Millons test	-
		Biuret test	-
		Ninhydrin test	-

Note: - Negative; + Positive

Table 2: Physicochemical characterization of Orange peel pectin powder

Parameter	Results
Colour	Brown colour
Odour	Characteristic
Nature	Amorphous
Solubility	Soluble in water insoluble in acetone, methanol, ether, ethanol.
pH	6.36 ± 0.76
Angle of repose	27.13° ± 0.15
Bulk density (g/cc)	0.613 ± 0.05
Tapped density (g/cc)	0.65 ± 0.07
Carr's index	12.45 ± 0.13
Hausner's ratio	1.058 ± 0.16
Viscosity (cps) (5%&7.5%)	61.23 & 59.62
Melting point (° C)	187
Microbial count	0
Loss on drying (%)	98± 0.56
Total ash (%)	6.25±0.59
Water soluble ash (%)	5.89±0.89
Acid insoluble ash (%)	0.89±0.78

Table 3: Formulation of Aceclofenac tablets using different amounts of Orange peel pectin powder as binding agent

Ingredients	Percentage of Orange peel pectin powder as binder (%w/w)				PVP as reference
	F1 (2.5 %)	F2 (5.0 %)	F3 (7.5 %)	F4 (10.0%)	F5 (7.5 %)
Aceclofenac (mg)	100	100	100	100	100
Orange peel pectin powder powder (mg)	5	10	15	20	--
PVP (mg)	--	--	--	--	15
Mannitol (mg)	85	80	75	70	75
Sodium starch glycolate (mg)	4	4	4	4	4
Magnesium stearate (mg)	4	4	4	4	4
Talc (mg)	2	2	2	2	2
Total (mg)	200	200	200	200	200

Table 4: Formulation of Aceclofenac suspensions using different percentages of Orange peel pectin powder as suspending agent

Ingredients	Percentage of Orange peel pectin powder as suspending agent (%w/v)				Sodium CMC as reference
	F6 (0.5 %)	F7 (1.0 %)	F8 (1.5 %)	F9 (2.0 %)	F10 (1.5 %)
Aceclofenac (g)	1	1	1	1	1
Orange peel pectin powder powder (g)	0.25	0.5	0.75	1.0	--
Sodium CMC (g)	--	--	--	--	0.75
Methyl paraben (g)	0.15	0.15	0.15	0.15	0.15
Propyl paraben (g)	0.1	0.1	0.1	0.1	0.1
Vanillin flavour (g)	0.005	0.005	0.005	0.005	0.005
Purified water q.s. to (ml)	50	50	50	50	50

Table 5: Pre compression parameters of aceclofenac granules

S. No.	Parameters	Formulation code				
		F1	F2	F3	F4	F5 (PVP)
1	Percentage yield	97.26	94.73	96.13	95.66	95.32
2	Angle of repose (ɵ)	26°27'±0.15	27°12'±0.27	29°13'±0.32	29°26'±0.64	27°52'±0.12
3	Bulk density (g/cc)	0.58±0.01	0.61±0.01	0.63±0.005	0.64±0.01	0.54±0.01
4	Tapped density (g/cc)	0.64±0.01	0.63±0.05	0.60±0.01	0.62±0.01	0.59±0.005
5	Carr's index	11.37±0.91	13.64±0.94	12.58±1.47	10.24±0.15	11.50±1.01
6	Hausner's ratio	1.11±0.01	1.13±0.04	1.13±0.02	1.09±0.005	1.11±0.01

Table 6: Post compression parameters of aceclofenac tablets

S. No.	Parameters	Formulation code				
		F1	F2	F3	F4	F5 (PVP)
1	Weight variation (mg)	200 ±0.011	200 ± 0.15	200 ± 0.08	200 ± 0.02	200 ± 0.01
2	Thickness (mm)	3.17±0.02	2.52 ± 0.02	2.48±0.02	2.21±0.02	2.29 ±0.02
3	Friability (%)	0.89±0.04	0.91±0.02	0.78±0.05	0.42±0.09	0.46±0.08
4	Hardness (kg/cm²)	3.05±0.12	3.72±0.09	4.22±0.13	5.89±0.04	5.69±0.07
5	Drug content (%)	101.25±0.56	99.86±0.12	99.66±0.22	100.02±0.36	100.88±0.78
6	Disintegration time(sec)	254	252	365	405	372

Table 7: Evaluation properties of aceclofenac suspension

Formulation code	Colour	Taste	Drug content (%)	Flow rate (ml/min)	Viscosity (cps)		Degree of flocculation	Particle size (µm)
					25 rpm	50 rpm		
F6	Off white	Sweet	101.06	1.66	21.58	14.59	1.08	15
F7	Off white	Sweet	99.12	1.21	22.45	13.26	1.12	18
F8	Off white	Sweet	98.23	0.90	26.12	17.89	1.23	17
F9	Off white	Sweet	97.15	0.50	26.78	17.94	1.12	12
F10	Off white	Sweet	100.84	0.40	27.56	18.12	1.18	14
Marketed	Orange	Sweet	100.03	0.30	29.69	21.22	1	8

Table 8: Sedimentation volume of aceclofenac suspensions prepared with different amounts of Orange peel pectin powder as suspending agent

Time (days)	Percentage sedimentation volume (F = Vu/Vo x 100)					Marketed product (IMOL)
	F6 (0.5% w/v)	F7 (1.0% w/v)	F8 (1.5% w/v)	F9 (2.0% w/v)	F10 (Reference) (1.5% w/v)	
0	100	100	100	100	100	100
1	92	94	98	100	100	100
2	84	90	94	100	100	100
3	80	90	94	100	100	100
4	76	90	92	100	100	100
5	72	88	88	98	98	100
6	70	84	86	98	98	100
7	64	82	86	98	98	100

Table 9: Redispersibility and pH of aceclofenac suspension

Formulation code	Redispersibility (No. of turns)				pH			
	1st day	7th day	14th day	21st day	1st day	7th day	14th day	21st day
F6	2	2	3	3	5.86±0.54	5.28±0.25	5.89±0.16	5.57±0.21
F7	2	2	2	3	5.46±0.32	5.31±0.21	5.38±0.15	5.45±0.18
F8	2	2	2	2	5.27±0.21	6.25±0.23	6.56±0.25	6.89±0.16
F9	1	2	2	2	6.82±0.15	6.78±0.35	6.69±0.31	6.48±0.36
F10	1	1	1	2	6.33±0.42	6.52±0.46	6.41±0.42	6.80±0.38
Marked product	No sediment	No sediment	No sediment	No sediment	6.09±0.48	5.84±0.59	5.47±0.57	5.85±0.54

Table 10: Cumulative amount of drug released from aceclofenac tablets prepared with different amounts of Orange peel pectin powder and synthetic binding agent PVP (7.5 %w/w). (n=3)

Time (mins)	Formulation code					
	F1	F2	F3	F4	F5 (PVP)	Marketed Product
0	0	0	0	0	0	0
10	15.50±0.55	17.39±0.12	13.61±0.10	10.20±0.06	10.32±0.07	11.12±0.78
20	29.52±0.01	28.02±0.02	29.14±0.30	23.46±0.26	26.85±0.11	24.75±0.85
30	44.69±0.10	38.63±0.12	39.77±0.16	36.39±0.25	38.12±0.10	38.12±0.33
40	62.15±0.50	51.17±0.30	44.36±0.42	40.56±0.32	44.16±0.61	44.16±0.33
50	86.45±0.35	65.99±0.32	55.06±0.18	49.69±0.06	52.12±0.49	52.12±0.13
60	97.52±0.15	78.17±0.26	64.15±0.13	65.27±0.05	61.78±0.36	61.78±0.26
70	97.54±0.05	88.48±0.37	70.28±0.33	74.51±0.04	72.85±0.34	72.85±0.89
80	97.58±0.22	99.55±0.37	82.47±0.23	77.53±0.38	84.56±0.85	82.56±0.25
90	97.59±0.05	99.56±0.37	88.48±0.25	85.94±0.42	99.32±0.14	99.12±0.45
100	97.61±0.24	99.57±0.37	99.69±0.26	90.20±0.44	99.34±0.15	99.14±0.47
110	97.62±0.05	99.59±0.37	99.70±0.27	95.98±0.45	99.35±0.16	99.15±0.48
120	97.62±0.05	99.60±0.37	99.71±0.29	99.86±0.48	99.37±0.18	99.16±0.49

Table 11: Cumulative drug released from aceclofenac suspension prepared with different amounts of Orange peel pectin powder and synthetic suspending agent sodium CMC (1.5 %w/v). (n=3)

Time (mins)	Formulation code				
	F6	F7	F8	F9	F10
0	0	0	0	0	0
2	14.36±0.53	15.50±0.29	13.98±0.88	10.96±0.45	16.18±0.78
4	29.90±0.58	27.25±0.56	19.68±0.87	20.43±0.86	31.82±0.92
6	38.64±0.59	37.50±0.92	31.81±0.54	28.03±0.87	48.65±0.78
8	54.96±0.39	47.38±0.85	36.77±0.53	31.09±0.29	59.72±0.76
10	62.59±0.54	56.14±0.67	47.79±0.58	37.56±0.39	62.16±0.73
12	75.15±0.75	72.86±0.68	56.17±0.63	46.30±0.43	78.82±0.12
14	82.04±0.79	78.99±0.46	67.58±0.87	55.06±0.27	82.12±0.38
16	97.34±0.82	89.30±0.71	75.23±0.83	67.61±0.29	91.34±0.87
18	97.36±0.89	97.12±0.64	80.99±0.49	75.26±0.96	99.62±0.56
20	97.38±0.92	97.59±0.74	89.78±0.76	89.72±0.43	99.64±0.38
22	97.39±0.94	97.61±0.76	98.72±0.77	97.39±0.45	99.65±0.40
24	97.40±0.95	97.63±0.78	98.89±0.78	99.39±0.46	99.66±0.42

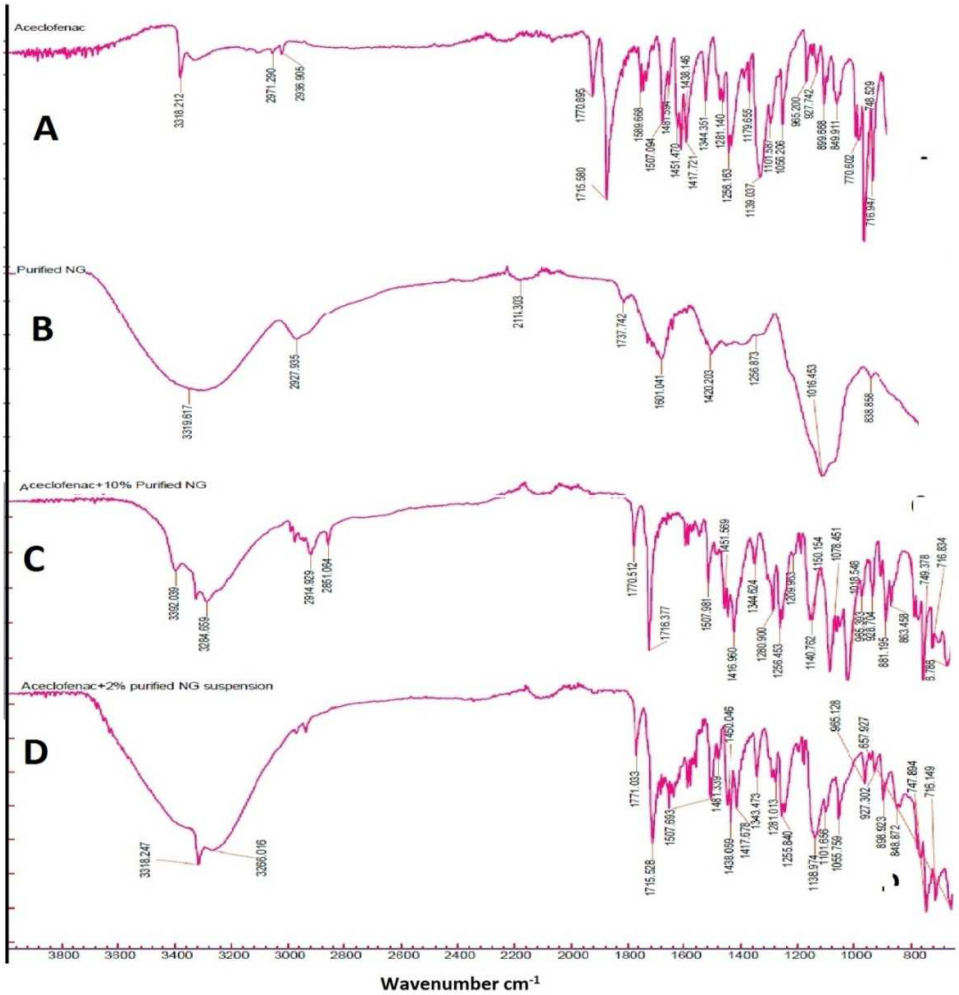

Figure 1: FTIR spectra of aceclofenac, Orange peel pectin powder, Aceclofenac tablet Formulation F4 and Aceclofenac suspension Formulation F9

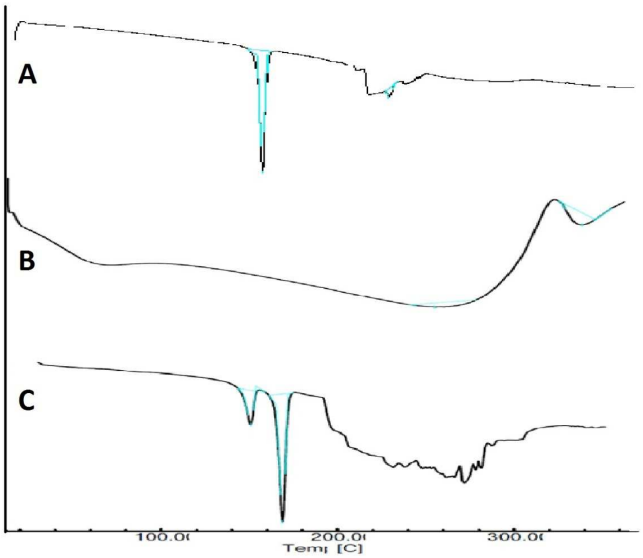

Figure 2: DSC thermogram of aceclofenac, Orange peel pectin powder and Formulation F4

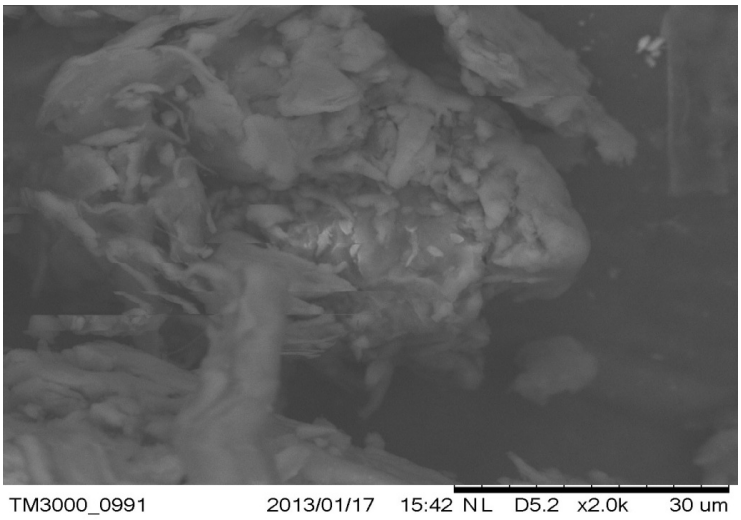

Figure 3A: SEM photograph of Orange peel pectin powder (2.0 k, Magnification)

Figure 3B: SEM photograph of Orange peel pectin powder (1.2 k, Magnification)

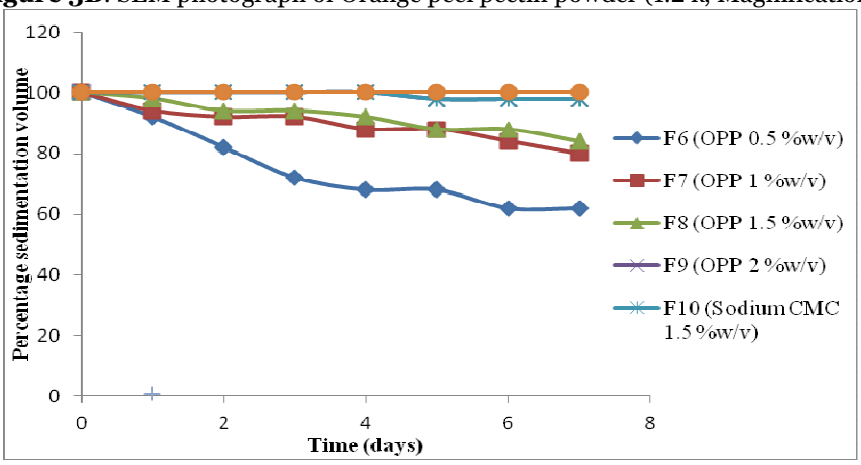

Figure 4: Percentage sedimentation volume of aceclofenac suspensions prepared with different concentrations of Orange peel pectin powder (OPP) compared with sodium CMC.

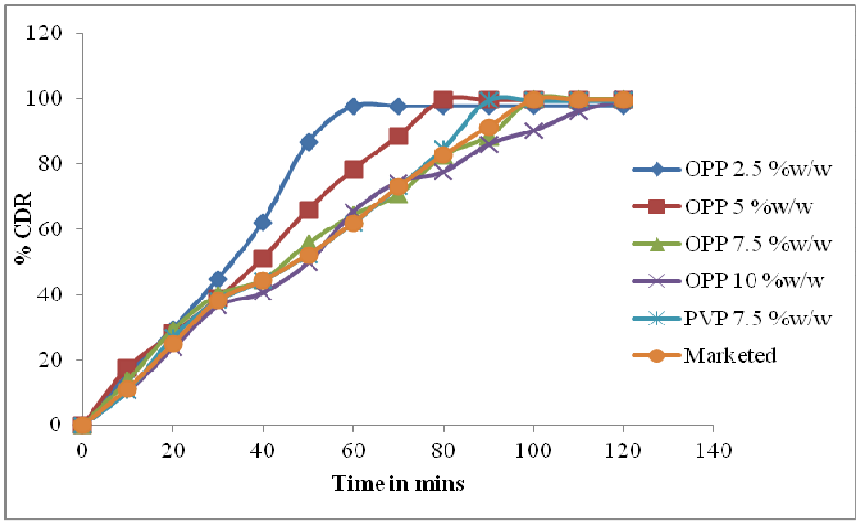

Figure 5: Comparison of dissolution profile of tablets prepared with Orange peel pectin powder (OPP) as binder, synthetic binding agent PVP and marketed product.

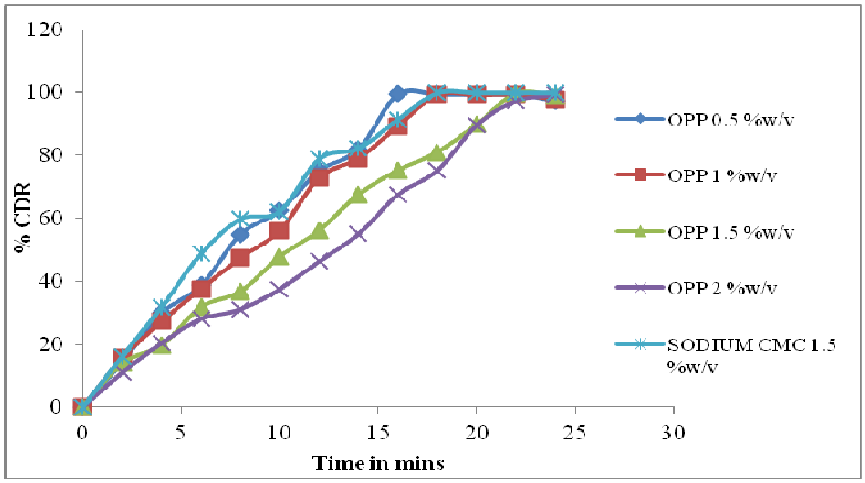

Figure 6: Comparison of dissolution profile of suspension prepared with Orange peel pectin powder (OPP) as suspending agent and synthetic suspending agent (1.5 %w/v).

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