Synthesis, Characterization, And Comparative Evaluation of derivatives of Natural Polysaccharide obtained from Cyamopsis tetragonolobus seeds as Film Forming and pH-Dependent Controlled Release Tablet Coating Polymer.

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Abstract:

The development of drug delivery systems that can provide controlled release of drugs is an important area of research in the pharmaceutical industry. The use of natural polymers, such

as guar gum, as excipients in drug formulations has gained significant attention due to their biocompatibility, biodegradability, and low toxicity.

In this study, galactomannan esters, namely guar acetate and guar acetate maleate, were synthesized from guar gum and their release retardant properties were compared. Guar acetate maleate was found to be a more effective release controlling excipient compared to guar acetate due to its pH-dependent drug release behaviour. The drug-polymer compatibility study showed that there was no interaction between the synthesized polymers and diclofenac sodium, indicating that the polymers can be used as release controlling excipients. The in vitro dissolution studies revealed that the drug release was pH-dependent, with the drug being released only in basic pH. This property of the synthesized polymers can be utilized to develop enteric-coated tablets, which can protect the drug from the acidic environment of the stomach and release it in the alkaline environment of the small intestine. The use of natural polymers in drug delivery systems has several advantages over synthetic polymers. Natural polymers are biocompatible, biodegradable, and non-toxic, which makes them suitable for use in biomedical applications. Additionally, the use of natural polymers can reduce the environmental impact associated with synthetic polymers.

In conclusion, the synthesized galactomannan esters, guar acetate, and guar acetate maleate, demonstrated controlled release properties and can be potentially used in the development of novel drug delivery systems. The use of natural polymers in drug delivery systems can provide a safer and more sustainable alternative to synthetic polymers.

Keywords: Guar gum, mixer- esterified derivatives, film formation, pH dependant solubility, sustain release.

Introduction:

The development of new drug delivery systems has become essential to overcome the limitations of traditional solid dosage forms. One of the main challenges in oral drug administration is the low and inconsistent bioavailability of drugs, which can result in suboptimal therapeutic effects and harmful side effects.[1] To overcome these issues, researchers have been exploring the use of innovative drug delivery systems that can improve drug efficacy, safety, and patient compliance. Polymer-based drug delivery systems have gained significant attention in recent years due to their ability to improve drug solubility, stability, and bioavailability. [1,2] Polysaccharide coatings are a particular class of polymers that

have been extensively investigated for their functional and aesthetic properties. These coatings can improve the release characteristics of drugs, increase their shelf life, and enhance their taste and odour, making them more acceptable to patients. Moreover, polysaccharide coatings can also protect drugs from harsh gastrointestinal conditions and first-pass metabolism, thereby improving their bioavailability. Some of the commonly used polysaccharides for drug coating applications include chitosan, alginate, and cellulose derivatives. In addition to enhancing drug performance, polymer-based drug delivery systems can also provide targeted drug delivery to specific sites in the body. [3] For example, nanocarriers made of polymers can be designed to target specific cells or tissues, enabling efficient drug delivery with minimal toxicity. In conclusion, the use of polymers, especially polysaccharide coatings, has revolutionized drug delivery systems by improving drug efficacy, safety, and patient compliance. [4] The development of innovative drug delivery systems will continue to play a vital role in the pharmaceutical industry, providing better treatment options for patients with different medical conditions. Naturally obtained polysaccharides can be treated chemically to obtain derivatives with film forming properties and have a pH dependant solubility. [5]

Chemical modifications of polysaccharides:

Polysaccharides are unique biopolymers with an enormous structural diversity. Huge amounts of polysaccharides are formed biosynthetically by many organisms including plants, animals, fungi, algae, and microorganisms as storage polymers and structure forming macromolecules due to their extraordinary ability for structure formation by supramolecular interactions of variable types. [6] In addition, polysaccharides are increasingly recognised as key substances in biotransformation processes regarding, e.g., activity and selectivity. Although the naturally occurring polysaccharides are already outstanding, chemical modification can improve the given features and can even be used to tailor advanced materials.[7] Etherification and esterification of polysaccharides represent the most important transformations as they provide easy access to a variety of bio-based materials with valuable properties. In particular, esterification can yield a broad spectrum of polysaccharide derivatives.[8,9] Also, simple esterification of the most abundant polysaccharides, cellulose and starch are commercially accepted procedures. [10,11] Chemical modification of gums not only minimizes certain formulation related drawbacks but also enables their use for specific drug delivery purposes. [12] In light of the above, the present study is aimed at providing a comprehensive review of the

various modifications made on gums to make them suitable for modified drug delivery applications.

Guar Gum- Natural Polysaccharide selected for the study:

It is white to yellowish-white, nearly odourless, free-flowing powder and primarily the ground endosperm of the seeds from Cyamopsis tetragonolobus (L.) Taub. (Fam. Leguminosae) mainly consisting of high molecular weight (50,000-8,000,000) polysaccharides composed of galactomannans; mannose:galactose ratio is about 2:1. The seeds are dehusked, milled and screened to obtain the ground endosperm (native guar gum). The gum may be washed with ethanol or isopropanol to control the microbiological load (washed guar gum). It is used as a thickener, stabilizer, emulsifier in various pharmaceutical formulations.

MATERIALS AND METHODS

Materials:

The gift sample of guar gum was obtained from Premcem Gums Pvt. Ltd, Mumbai, India. Gigt samples of Xanthan gum and Carob gum were received from Hexon Laboratories Private Limited, Nashik, Maharashtra. Other chemical reagents like formic acid, acetic acid, acetic anhydride, maleic anhydride o- phosphoric acid, sulphuric acid & acetone were procured from Merk (India). The selected NSAID API: Diclofenac sodium was obtained from Emcure Pharmaceuticals Pune, India. All the chemicals used for synthesis were of A. R. grade. The reactions were carried out by conventional method.

Methods:

Synthesis of Guar gum mixed ester[13]

Step I: Formylation

Formylation of the natural polysaccharides was carried out by treating the gum with formic acid for a period of 48 hours. The hydroxyl group of the gum formed a linkage with the carbonyl group of formic acid, with loss of a water molecule to form the formate derivative. The gum, as such being less reactive, is activated by formylation.

Step II: Acetylation

Activated derivative of the gum i.e. gum formate is subjected to esterification to form esters & mixed ester derivatives. Esterification at hydroxyl group with carboxylic acid anhydrides can be conveniently catalysed. The method involves converting the acid anhydride to a more

powerful acetylating agent by protonation of one of its carbonyl oxygen. The addition of few drops of sulphuric acid is sufficient to catalyze the reaction. Optimizing and monitoring the exact temperature specific to a particular polysaccharide is the critical step to obtaining the derivative with desired physiochemical properties required for film formation and further act as a tablet coating polymer.

Characterization of guar gum mixed esters

Characterization of guar acetate and guar acetate maleate has been done using following techniques.

Organoleptic properties

The synthesized derivatives were analyzed for characterized for different organoleptic properties like colour, odour and appearance.

Spectral analysis: FT-IR study

Determination of the functional groups is a necessary parameter in structural elucidation of any derived substance. FT-IR spectra of native and derivatised samples (4 mg) blended with solid KBr (100 mg) were scanned from 400 to 4000 cm^{-1} in a Shimadzu FTIR-8400S (Japan). IR solution software was used to analyse the sample.

Spectral analysis: Proton ^{1}H NMR

Determination of the position & number of different environments of protons within a molecule can be determined by analyzing the sample using Proton Magnetic Resonance (PMR). ^{1}H NMR spectrum of the sample was recorded in Varian Mercury YH-300 NMR spectrometer at a constant temperature of $22\pm2^{o}C$ using duteriated chloroform ($CDCl_3$) as a solvent.

Solubility

For the determination of solubility 2.5g of material with 50 ml of solvent was placed in an airtight screw-capped tube and agitated for 2 h at 25 ◦C. Two milliliters of supernatant was withdrawn in a tared dish. Solvent was evaporated by a mild heat and the tared dish was weighed again. The difference in weight gives the amount of material dissolved in the solvent. Different solvents like chloroform, acetone, isopropyl alcohol, ethanol and water and different pH solutions with pH 1.6, 4.0, 6.8 and 8.0 were used for this purpose, and the

experiment was repeated three times for each solvent/buffer solution. Buffers of different pH were prepared by the method described in Indian Pharmacopoeia-2007.

Acetyl content and degree of substitution (DS)

Acetyl content and DS were determined by titration method. Acylated gum (1.0 g) was taken in a 250 ml flask and 75% ethanol (50 ml) was added. The solution was stirred at 50 °C for 30 min at 40rpm in shaker cum incubator and cooled to room temperature and then 0.5 N KOH (40 ml) was added with swirling. The flask was stoppered and allowed to stand for 72 h for complete saponification. The excess of alkali was back titrated with 0.5 N HCl using phenolphthalein indicators. The solution was allowed to stand 2 h and additional alkali which might leach from the sample was titrated. A blank was titrated in parallel. The acetyl content and DS was calculated by using equation I & II[14,15]

Equation I:

$$\%\ \text{Acetyl content} = \frac{[(\text{VB} - \text{VS}) \times \text{molarity of HCl} \times \text{M acetyl} \times 10^{-3} \times 100]}{\text{sample weight (g)}}$$

VB in ml is the volume of 0.5N HCl used to titrate the blank; VS in ml is the volume of 0.5N HCl used to titrate the sample; M acetyl is the formula weight of acetyl group.

Equation II:

$$\text{DS} = \frac{(162 \times \text{Acetyl}\ \%)}{\text{M acetyl} \times 100 - ((\text{M aetcyl} - 1) \times \text{Acetyl}\ \%)}$$

(M acetyl = 43) where 162 is the molecular weight of glucose units.

Free film preparation.

Free film of guar esters were prepared by solvent evaporation technique on a mercury substrate. A 30% (w/v) solution was prepared in acetone and poured in a petridish containing mercury (area of casting: 20 cm^2) allowing the solvent to evaporate for 24 h. Films were stored in desiccators at ambient temperature for 24 h before study. Film thickness was

measured by a thickness gauge (Oswal Scientific, Ambala, India) and recorded as mean of three determinations. [16,18]

Characterization of free films

Water vapour transmission rate (WVTR) studies

Films were cut into appropriate dimensions and mounted on a permeation cell containing saturated salt solution (excess salt) of potassium acetate, potassium carbonate, sodium chloride and potassium nitrate to provide relative humidity (RH) conditions of 23, 43, 75 and 93%, respectively (Patel et al., 1964). The charged cells were weighed and placed in pre-equilibrated desiccators maintained at 0% RH. The cells were reweighed at the end of 24 h. The amount of water transmitted (W) through the film was given by the weight loss of assembled cell. The WVTR was computed using Utsumi's equation (Utsumi et al., 1961) taking the film thickness into consideration using equation III. [17,20]

Equation III:

$$\mathbf{Q = \frac{WL}{S}}$$

where, W: gram of water transmitted/24 h, L: film thickness (cm), S: surface area (cm^2), Q: water vapour transmission (g cm/cm^2/24 h).

Moisture absorption by free films

Films were transferred to a tarred petridish and transferred to glass desiccators maintained at controlled relative humidities of 23, 43, 75 and 93%, respectively. The relative humidity in the chamber was controlled by the use of different saturated solutions containing excess solute. The film specimens were accurately weighed, placed in relative humidity chambers, removed and weighed again at the end of 14 days. [19,21,22] Increase or decrease in weight and changes

in physical appearance were than observed. Percent moisture absorption was calculated by using equation IV:

Equation IV:

$$\%\textbf{moisture absorbance} = \frac{(\mathbf{A} - \mathbf{B})}{\mathbf{A}} \times \mathbf{100}$$

where A: weight of conditioned film; B: initial weight of film.

Scanning electron microscopy

Surface morphology was studied under scanning electron microscope. The dry film sample, spread on a double-sided conducting adhesive tape, pasted on a metallic stub, was coated with platinum in a sputter coating unit for 2 min and observed in a Jeol JXA-840A (London, UK).

Mechanical properties

Films were stored in desiccators at ambient temperature for 24 h before study. Film thickness was measured by a thickness gauge (Oswal Scientific, Ambala, India) and recorded as mean of three determinations. Free films were evaluated for the mechanical properties by a plastic tensile test, performed on Instron Instrument based on ASTM D-412 test. The measurements were made at a gauge length of 50 mm, cross head speed (CHS) of 25 mm/min at 50% RH and 25°C. The tensile strength, percent elongation and modulus of elasticity were computed with at least three repetitions.

Formulation of tablet:

The ingredients sufficient for a batch of 50 tablets according to formula as mentioned in Table No. 01, was sifted through sieve No.80. Wet granulation method was used for the purpose of granulation using 10% starch solution. The wet mass was passed through sieve No.12 and the granules were dried in a hot air oven at not more than 40°C. Dried granules were passed through sieve no.16. Geometrical mixing was done with lubricant magnesium stearate to ensure complete mixing. [23] Tablets containing Diclofenac sodium equivalent to 50 mg were compressed by using 8.0 mm diameter, spherical tablet punches on a 10 station rotary compression machine(Rimek minipress machinery Co.Pvt.Ltd., India) at the hardness of 4 to 5 kg/cm^2.

Table No: 01 Formula for tablet formulation

Ingredients	Quantity
Diclofenac sodium	50 mg
Lactose	50 mg
Microcrystalline cellulose	100 mg
Magnesium stearate	1 mg
Starch (10% solution)	q.s.

Evaluation of tablet:

Tablet thickness and Diameter:

Thickness and diameter of tablet provide necessary information about variation between the tablets. Thickness and diameter of 10 tablets was measured using Vernier calipers. The test was performed in triplicates.

Hardness:

This test is used to check the hardness of a tablet which may undergo chipping or breakage during storage, transportation and handling. In this five tablets were selected at random and the hardness of each tablet was measured with Monsanto hardness tester. The hardness is usually measured in terms of kg/cm^2.

Uniformity of weight:

This test is performed to maintain the uniformity of weight of each tablet which should be in the prescribed range, this is done by sampling and weighing 10 tablets at random and average weight is calculated. Not more than two of the individual weights deviate from the average weight. [24]

Friability test for uncoated tablets:

The friability test was performed using Roche friability tester apparatus. Friability of 20 tablets was determined. The tablets were weighed initially ($W_{initial}$) and transferred to the apparatus. The instrument was operated at 25 rpm for 4 min to run upto 100 revolutions. The tablets were weighed again (W_{final}). The % friability was then calculated by using the equation V. [25]

Equation V:

$$\% F = \frac{W_{initial} - W_{final}}{W_{initial}} \times 100$$

% friability of less than 1% is considered to be acceptable.

Coating of tablets:

The tablets were divided into three batches for coating them with the three synthesized polymers of each natural gum. Further each batch was subdivided into two batches (thus forming total 06 batches F1, F2, F3, F4, F5 & F6) for coating them with 8% w/v& 15% w/v polymeric solutions respectively for each polymer . 4% w/v polymeric solution was prepared in acetone and used for coating. [26,27] The polymeric solution was stirred in a magnetic stirrer for 1 h before coating. The INSTACOAT-PHARMA R&D COATER (Mumbai, India) machine was used for the purpose of coating. The spray nozzle was properly positioned to cover the entire tablet bed. The parameters set for tablet coating are mentioned in Table No: 02.

Table No: 02 Parameters for tablet coating

Parameter	Specification
Charge per batch	10 tablets
Speed of pan revolution	30rpm
Spray nozzle diameter	0.5mm
Pump rpm	1rpm
Drying air temperature	51^{o}C

In Vitro Drug Release & Comparative analysis:

In vitro dissolution of coated tablets (equivalent to 50 mg drug) was studied using USP XXIIIdissolution apparatus -II (Veego scientific, Mumbai, India) at 37℃ at a speed of 100 rpm as shown in the Table No: 03. The test was conducted in 900 ml of pH 1.2 solution for first 2 h followed by 900 ml pH 6.8 solution up to 6 h. Aliquots of 5 ml were withdrawn at a time intervals of 30 min. The sink condition was maintained by replacing the dissolution medium on withdrawal of aliquots andthe amount of drug released was monitored by measuring the UV absorbance of filtered solution at 276 nm using UV visible spectrophotometer (Systronics 2203). [29]

Table No: 03 Specifications for dissolution test

Parameter	Specification
Dissolution medium	Buffers (pH 1.2 & pH 6.8)
Temperature	37^{o}C
Volume of dissolution medium	900ml.
Rotation speed	100rpm
Sample volume	5ml
Running time	2 h in pH 1.2 & 4 h in ph 6.8

The % cumulative drug release (% CDR) in 6 h was calculated from the UV absorbance values of each aliquot. A plot of time versus % CDR was studied to determine the drug releasepattern for each batch of tablet. [30]

Result and Discussion:

The ester derivatives of guar gum, (GA, GAM & GAP) were synthesized successfully as per the optimized method used in the study. All the three esterified derivatives of Guar gum showed a good film property.

Organoleptic Properties

All the synthesized derivatives of natural polysaccharides showed similar characteristics with respect to their organoleptic properties. Table No.4 shows the characterization of the synthesized compounds

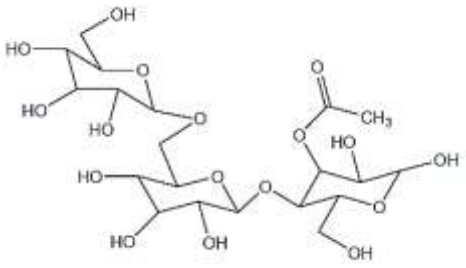
Table No: 04: Characterization of gum derivatives

Chemicals	Molecular formula	Mol. Wt.	%yield	Colour	Odour	Appearance
GF	C19H32O17	532	82.69	Yellow	Formic acid	Amorphous

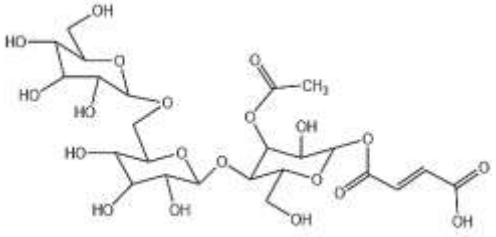
GA	$C_{20}H_{34}O_{17}$	546	72.55	White	Acetic acid	Amorphous
GAM	$C_{24}H_{36}O_{20}$	644	69.44	Off white	Acetic acid	Amorphous
GAP	$C_8H_4O_3$	695	78.34	White	Acetic acid	Amorphous

Spectral Studies

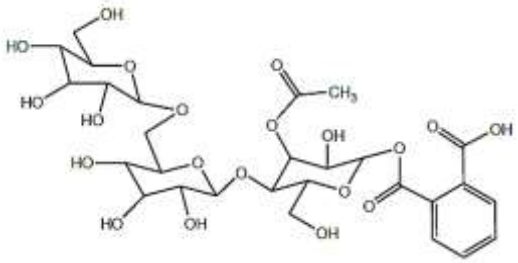
Structures of synthesized natural polysaccharide-ester and polysaccharide mixed ester derivatives were confirmed by FTIR & ^{1}H-NMR. All the spectral data were in accordance with the designed structures as follows:



Guar acetate



Guar acetate- maleate



Guar acetate- phthalate

Differential Scanning Calorimeter (DSC):

GA showed a slight higher Tg of 90ºC than the native GG. The Tg of GAM and GAP were however slightly lower than GG i.e. 70 ºC & 62 ºC respectively. Hence, from the DSC thermograms it was clear that all the synthesized derivatives of GG showed amorphous nature with lower glass transition temperatures.

Solubility

A study of relative solubility was carried out in different solvents. All three derivatives of \gum showed a good solubility in organic solvents like chloroform, acetone, isopropyl alcohol & ethanol without any solubility in water. On the other hand the natural gum was found to be soluble or sparingly soluble in water forming a thick solution. The solubility was also tested in solutions of different pH range from acidic to basic. Table No: 05 and 06 show the solubility profile in different solvents and different pH respectively

Table No:05 Solubility of Guar gum and its esters in different solvents

Solvents	**Solubility (g/ml)**			
	GG	**GA**	**GAM**	**GAP**
Chloroform	Insoluble	0.0384±0.0004	0.0381±0.00044	0.0382±0.00020
Acetone	Insoluble	0.0391± 0.0002	0.0389±0.00071	0.0420±0.00042
Isopropyl alcohol	Insoluble	0.0365± 0.00025	0.0372±0.00070	0.0374±0.00050
Ethanol	Insoluble	0.0345±0.00055	0.0334±0.00076	0.0336±0.00074
Water	Soluble	Insoluble	Insoluble	Insoluble

Each value is mean ± standard deviation of three determinations.

Table No: 06 Solubility of Guar Gum derivatives in different pH solutions

Solvents	**solubility (g/ml)**		
	GA	**GAM**	**GAP**
1.6	$5.2x10^{-3}$	$4.2x10^{-3}$	$2.8x10^{-3}$
4.0	$11.6x10^{-3}$	$8.4x10^{-3}$	$4.4x10^{-3}$
6.8	$28.4x10^{-3}$	$26.0x10^{-3}$	$23.8x10^{-3}$
8.0	$36.2x10^{-3}$	$33.6x10^{-3}$	$28.4x10^{-3}$

Each value is mean of three determinations.

Acteone being fesiable, was used as a solvent in the spray coating technique. The solubility increases with increase in the pH of the solution. A low solubility was found at a lower pHof 1.6. This indicates a minimum drug releasing property in the gastric acid environment. Similarly a higher solubility was found in the basic pH of 6.8 this indicates a maximum drug release in the intestine. Hence the coating polymers also protects the upper gastrointestinal

tract from the possible irritation due to the drug diclofenac sodium.

Mechanical properties of free films:

The results of the estimated mechanical properties of free films of gum ester derivatives are shown in Table No.07. All the gum esters have shown high

% elongation, which indicates the flexible film-forming properties of gum esters. The films exhibited very low tensile strength values. The variation in tensile properties of the films of different gum derivatives could be attributed to the difference in their chemical composition. Moreover, differences in molecular weight have a significant effect on the tensile properties of polymeric films. This indicates a better film-forming property suitable for the coating of tablet formulation with minimum chances of tablet coating defects.

Table No.07: Mechanical properties of the free films of GG esters

Film material	**Thickness (mm)**	**Tensile strength (MPa)**	**% Elongation**	**Young's modulus (MPa)**
GA	0.38 ± 0.03	0.517 ± 0.083	187.11 ± 67.43	53.13 ± 0.971
GAM	0.33 ± 0.02	0.662 ± 0.062	220.29 ± 93.52	47.07 ± 11.426
GAP	0.35 ± 0.02	0.379 ± 0.056	237.16 ± 108.17	34.81 ± 7.313

Water vapour transmission rate (WVTR) studies: Utsumi's equation was used to determine the water vapour transmission rate of the free films. As seen from the scanning electron microscopy studies, the films being porous showed a considerable amount of water vapour permeability. As shown in Table no. 08 the permeation increased with an increase in relative humidity level. The polymer of acetate-maleate derivatives of all gums showed a maximum WVT rate at a relative humidity of 93%.

Table No.08: Water vapour transmission rate at various % RH.

Derivative	**Film Thickness (cm)**	**area (cm^2)**	**Q (g cm/cm^2/24 h) at RH**			
			23%	**43%**	**75%**	**93%**
GA	0.38	7.06	$3.39x10^{-5}$	$7.01x10^{-5}$	$12.39x10^{-5}$	$29.46x10^{-5}$
GAM	0.33	7.06	$2.54x10^{-5}$	6.64x10-^{5}	$11.46x10^{-5}$	$28.17x10^{-5}$

GAP	0.35	7.06	$2.90x10^{-5}$	$6.23x10^{-5}$	$10.76x10^{-5}$	$27.62x10^{-5}$

Moisture absorbance study of free films: The results of moisture absorbance by the free films at an increasing amount of relative humidity are shown in Table no 09. It is seen that there was an increase in the % moisture absorbance with an increase in the relative humidity. Even at higher relative humidity level of 75 % & 93% the free films showed nearly 2% of moisture absorbance with a slight change in the physical appearance. The films becamesoft at the end of 14 days.

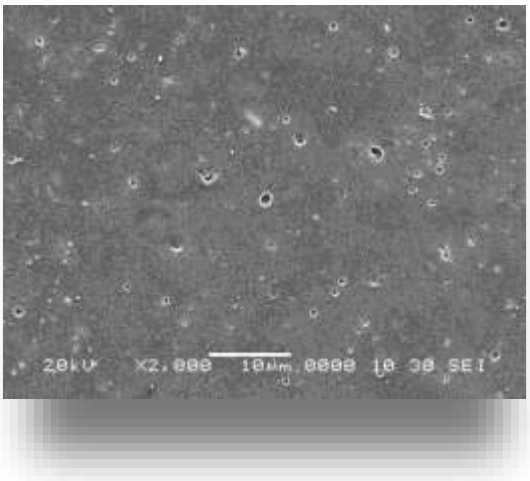
Table No.09: % moisture absorbed by free films at different RH.

Derivative	% moisture absorbed at RH			
	23%	43%	75%	93%
GA	0.846±0.038	1.164±0.0016	1.789±0.092	2.411±0.043
GAM	1.036±0.013	1.621±0.080	1.849±0.106	2.608±0.168
GAP	1.157±0.014	1.624±0.085	2.096±0.021	2.292±0.034

Scanning electron Microscopy:

All the films showed a smooth texture with presence of some minute pores. The pores were irregular in shape without any uniform distribution as shown in Fig 01. Therefore the SEM study of the films showed the surface morphology and texture suitable for the controlled drug release.

Fig 01: SEM of films of GA



Evaluation of tablets:

Weight variation: The result of weight variation of all the tablet formulations is shown in Table No: 21. All the tablets passed the test as the average % weight variation was within the pharmacopoeial limits of ±5%. The weight of all the tablets was found to be uniform with low standard deviation values.

Hardness test: Hardness of all the tablets was maintained within 4.5 to 5 kg/cm^2. The mean hardness value (n=3) were measured for each formulation using a Monsanto hardness tester. The results are tabulated in table No:21. The hardness value ranged from 4.5±0.1 kg/cm^2 to 4.8±0.1 kg/cm^2. Uniformity was depicted from low standard deviation.

Diameter test: The results for diameter test are shown in Table 21. The tablet mean diameter (n= 10) was found to be uniform in all the formulations & the values ranged from 8.0±0.1mm to 8.13±0.2mm. Low standard deviation indicates the uniformity within the diameter of tablets.

Friability test: Another measure of tablet strength is friability. The values of friability test are given in Table 21. The % friability of all the formulations was below 1% indicating that the friability was within the prescribed limits. Thus the results of friability test indicate that the tablets possessed good mechanical strength.

Table No:10 Evaluation of tablet formulation

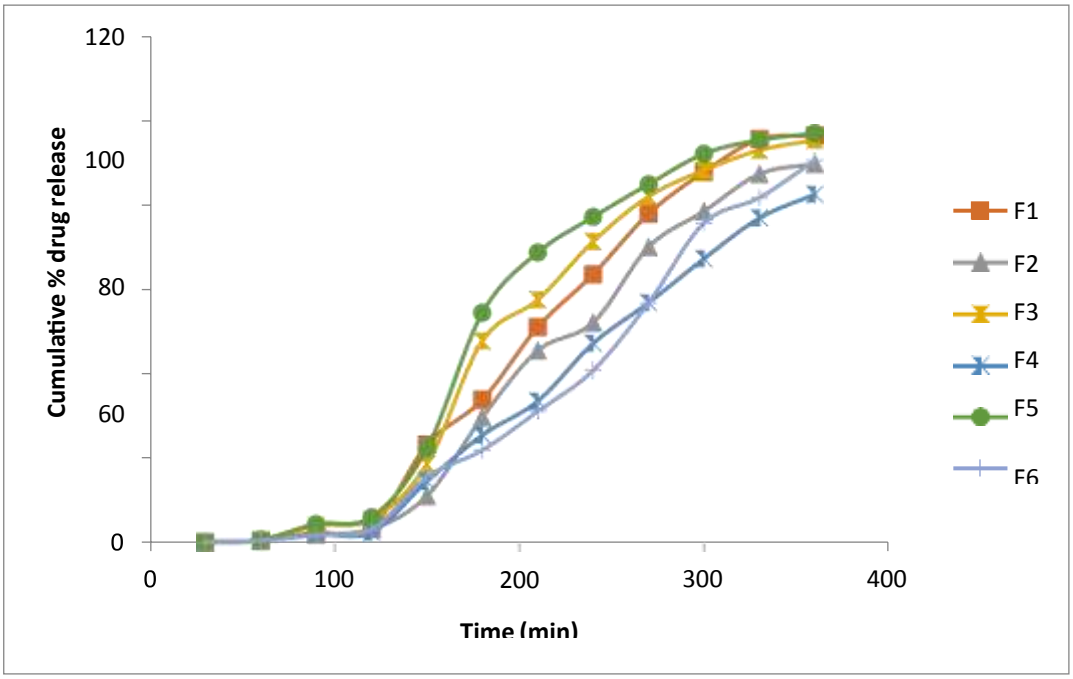
Test	Batch					
	F1	**F2**	**F3**	**F4**	**F5**	**F6**
Weight (gm)	200.2±0.29	200.3±0.22	201±0.13	200.2±0.34	199±0.11	200±0.12
Diameter(mm)	8.12±0.2	8.11±0.2	8.03±0.5	8.13±0.2	8.0±0.1	8.06±0.2
Hardness	4.8±0.0	4.8±0.1	4.6±0.2	4.5±0.2	4.5±0.1	4.5±0.1
% Friability	0.12	0.16	0.22	0.09	0.49	0.14

In-vitro Dissolution Studies:

Sequential studies in two different media were performed to evaluate the drug release characteristics of all the formulations by the paddle method. The in-vitro release data for the various formulations of Diclofenac sodium are provided in following tables, along with the graphs of %cumulative drug release Vs time (min.) to compare the drug release from tablets coated with varying percentage of different polymers. From the data it is clear that the formulations F3 & F4 of the derivative GAM showed an optimized %cumulative drug release pattern with a extended drug

release period of more than 6 hours.Also it should be noted that all the formulations ofthe three guar gum derivatives showed a controlled drug release pattern with a minimum drugrelease at pH 1.2 & an increasing drug release pattern in the basic pH of 6.8. Nearly all the formulations showed a sigmoid shaped graph of %cumulative drug release Vs time (Fig 02) as shown in the graph below:

Figure 02: A comparative graph of dissolution profile of Guar derivative F1- F6



Conclusion:

Guar gum, a natural polysaccharide, was used to successfully synthesize two semi-synthetic derivatives, guar acetate, guar acetate maleate and guar acetate phthalate. The resulting products were analyzed through spectroscopic studies and other physicochemical tests to determine their properties. This study aimed to compare the film forming and coating properties of the three polysaccharide derivatives. The relative solubility, mechanical properties, water vapor transmission rate, moisture absorbance, and SEM studies indicated that both guar acetate and guar acetate maleate had good film forming properties. Tablet formulation batches were coated with these polymers to evaluate their efficacy in controlling drug release. Both guar acetate and guar acetate maleate were able to control drug release for up to 6 hours. Guar acetate maleate was found to be a better controlled release tablet coating polymer, with a cumulative % drug release of 82% after 6 hours. It is noteworthy that all formulations of the three guar gum derivatives showed a controlled drug release pattern, with minimum drug release at pH 1.2 and an increasing drug release pattern in the basic pH of 6.8.

These biomaterials have the potential to be economically viable and biodegradable alternatives to existing materials used in drug delivery systems. Further research is required to investigate the potential

of these synthesized derivatives in the design of film-coated sustained drug delivery devices.

Conflicts of interest:

The author declares no conflicts of interest.

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