ORIGINAL ARTICLE

Novel extraction and application of okra gum as a film coating agent using theophylline as a model drug

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ABSTRACT

The purpose of this study was to investigate the effect of extraction and application of okra gum as an aqueous film coating agent. Powdered okra pods dispersed in demineralized water was heated at 80 ± 2°C for 30 minutes in the presence of sodium chloride. The filtrate was successively centrifuged at 4000 rpm for 30, 60, or 120 minutes and freeze dried. The samples were used as film former at different concentrations in aqueous film coating operations. Near infrared (nIR) absorption spectra, photomicrographs, and some physicochemical properties of the coated tablets were evaluated. The okra gum samples had different nIR spectra and possessed good processing and application quality due to relatively low viscosity. A six-fold concentration of this gum from the novel extraction yielded glossy theophylline tablets within a short time. A t (18) = 2.895, $P < 0.005$, t critical = 1.734 were obtained for the independent analysis of the hardness of core and coated theophylline tablets. A 3.0% concentration of the okra samples at a flow rate of 3 ml/min for 100 minutes showed that F = 3.798, DF = 29, $P < 0.035$, F critical = 3.354 in tablet hardness among samples and F = 15.632, DF = 29, $P < 0.0001$, F critical = 2.152 were obtained on film thickness among tablet samples during the coating and drying operation. Novel extraction process enhanced the film coating potential of okra gum by delivering more solids on the substrate at a shorter time with improved operation efficiency.

Key words: Application, film former, laboratory coater, okra gum, extraction method, viscosity

INTRODUCTION

Film coating of pharmaceutical oral solid dosage forms has been widely used for functional and non-functional purposes, to coat tablets, capsules, granules, powders, and pellets.[1,2] Today, it is more common to use aqueous solvent than organic solvents, because aqueous solvent is non-flammable, environmental-friendly, cheap, readily available, and safe. Film coating is preferred to sugar coating because it involves low weight increase of 2 to 3% and less rigid coats which reduce the cracking and other defects observed in sugar coating.[1] Among other benefits,[3,4] polymer is the main ingredient in a film coating operation and could be a natural or synthetic polymer.[1,2]

Okra gum is a natural polymer obtained from the pods of okra plant (*Abelmoschus esculentus*). It has been used as a binder,[5,6] hydrophilic polymer matrix,[7] suspending,[8] and bioadhesive agents.[9] The potential of okra gum, obtained by traditional extraction, as a film coating agent was reported.[10] The use was limited to 0.62% w/v in a laboratory coating equipment due to high viscosity when the gum was extracted using the traditional method.[11] The present study was an attempt to improve on the flow and spray characteristics of okra gum for use as a film-coating agent in conventional laboratory coating equipment by modifying the viscosity through a novel extraction method. The samples obtained were used as aqueous film formers in the coating of theophylline tablets in a laboratory coating equipment.

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Theophylline was used as the model drug in this study. Theophylline is a drug that has been used for several decades in the treatment of asthma.[12] It is a readily available drug, widely used as a model drug in coating operations in drug product development involving many polymers.[13-18]

MATERIALS AND METHODS

Materials

The materials used in this study were donated to the laboratory by the respective manufacturers as indicated. Theophylline and magnesium stearate (Spectrum Chemicals, Brunswick, New Jersey, USA), microcrystalline cellulose (Mendell Apenwest Company, NY, USA), silicon dioxide Aerosil 200 (Degussa Corporation, NJ, USA), pregelatinized starch (National Starch Food Innovation, NJ, USA), Glycerin (Parchem fine and Specialty chemicals, New Rochelle, New York, USA), and okra gum (from matured *okra pods*, harvested in July, 2010 in Jos, Plateau State of Nigeria) and processed in our laboratory. All other reagents were of analytical grade.

Methods

Extraction of okra gum

The method of ogaji and Hoag[19] was adopted in the extraction of okra gum samples. Briefly, a 100 g powdered sun-dried okra pods was dispersed in about two liters of demineralized water with continuous stirring on a magnetic stirrer. The dispersion was heated at 80 ± 2°C for 30 minutes in the presence of 0.017 moles of sodium chloride, allowed to cool to room temperature at 25 ± 1.0°C, and screened through muslin to remove debris and sediments. The filtrate was centrifuged at 4000 rpm for 30, 60, or 120 minutes to obtain K2, K3, or K4 samples, respectively. The gum was washed severally with distilled water and freeze dried. A 50 g sample was dispersed in a liter of demineralized water, allowed to stand for 24 hours and extracted with ethanol 96% after clarification, to obtain sample K1.[11] The gum was dried at 50 ± 2°C for 24 hour.

Determination of viscosity

The viscosities of samples of the okra mucilage were determined on Brookfield rheometer (DV-III + model, Brookfield Engineering, USA) using CPE 40 according to the method described by Ogaji.[20]

pH determination

The determination of the pH of 1% w/v mucilage of okra gum samples was carried out using the Orion pH/ISE meter (Model 720 A, Thermo Electron Corporation, MA, USA) at 25°C.

Production of theophylline core tablets

The tablet formulation consisted of theophylline, pregelatinized starch, microcrystalline cellulose, silicon dioxide, maize starch, and magnesium stearate. Theophylline tablets were prepared by direct compression method to contain theophylline 50 mg per tablet. The tablets were compressed on a B2 instrumented rotary press (KEY Industries Pharmaingdale Inc. NJ, USA) to a target weight of 270.0 ± 27.0 mg.

Weight uniformity of theophylline tablets

The test was carried out according to the United States Pharmacopoeia and National Formulary (USP/NF) test method[21] using a Mettler Toledo analytical balance (Model AB 104-S, Switzerland).

Friability of Theophylline Tablets

The USP/NF test method[21] was used and the result was average of three replicates.

Hardness of theophylline tablets

The test was carried out on a KEY hardness tester (Model HT-300, KEY International Industries, USA) according to the USP/NF test method.[21]

Disintegration time of tablets

Disintegration time of Theophylline tablets in water was investigated using the disintegration apparatus maintained at 37 ± 1°C in a water bath (Haake water bath, USA) according to USP/NF test method.[21]

Dimensions of tablets

Ten tablets were randomly selected from each batch and their thicknesses and diameters were evaluated using an ASTM venier caliper (Model EC 06, Tresna Instruments, USA).

Near infrared spectra of theophylline tablets

Scanning and data acquisition on the two flat surfaces of the randomly selected twenty tablets were carried out on Vision software of the Near Infrared spectroscopy (Model 6500, Rapid Content Analyzer FOSS NIRSystem, USA) as described by Ogaji.[20]

Dissolution profile of the tablets

The dissolution rate profile was evaluated in a SR8-Plus automated dissolution apparatus (Hanson Research Corporation, USA) interfaced with spectroscopic software version 3.0 on UV 160 U- UV- visible recording spectrometer (Shimadzu Scientific Instruments, Japan). The dissolution medium was Millipore water, maintained at 37 ± 2°C. The paddle was rotated at 50 rpm and the absorbance of dissolved theophylline was measured at 272 nm every 5 minutes. Kinetic data acquired was transferred to Microsoft Excel for further processing.[20]

Film coating of tablets with okra gum samples

The film coating formula is shown in Table 1. Three graded coating suspensions of K1, K2, K3, or K4 sample of okra gum at 0.62, 1.2, and 3.0% w/v (represented by S1, S2, and S3, respectively) were formulated to assess the ease of flow and spray in a conventional laboratory coater.

Approximately 750 g dedusted, uncoated theophylline tablets was coated in a Hi-Coater (Model HCT-30, Freund Engineering, Japan) at the following conditions: Coating pan speed, 10 rpm; inlet air temperature, 56-60°C; outlet air temperature, 28-30°C; and atomizing air pressure, 0.5 bars. Uniform distribution of the solids in the coating suspension was maintained throughout the process with the aid of a magnetic stirrer. The flow rate of the coating suspension was initially 1.5 ml/min for 30 minutes which was maintained at 3.0 ml/min thereafter. In-process evaluations of the coating were carried out at 30 minutes interval and at 50, 75, 100, 125, or 150 ml utilization of coating suspension.

Determination of some physicochemical properties of coated theophylline tablets

Weight uniformity, dimensions, friability, disintegration time, hardness, and dissolution time of the coated theophylline tablets were evaluated as described under uncoated theophylline tablets above. The hardness of theophylline-coated tablet samples were statistically analyzed with the aid of Data Analysis software (Window 10, Microsoft Excel, Microsoft Corporation, USA).

Determination of film thickness on coated theophylline tablets

Ten coated tablets were randomly selected at 30 minutes interval and film thickness was evaluated by weight and microscopy (Nikon, Japan) fitted with camera.[20] Photomicrographs of the cross section of the tablets were obtained and the film thickness was determined at different points on the filmstrip with the aid of Post Basic software (Linkam Scientific Instrument, UK). The film thickness among samples of theophylline-coated tablets at the end of the coating process was statistically evaluated using one factor analysis of variance (ANOVA).

Effect of curing on some physicochemical properties of coated tablets

At the end of the coating process, the tablets were subjected to curing at inlet temperature of 60°C. Samples were taken at intervals for evaluation of the effect of curing on some physicochemical properties of the coated tablets. The effect of coating and curing on the film thickness on theophylline tablets drawn from different batches was analyzed with the aid of Data Analysis software (Window 10, Microsoft Excel, Microsoft Corporation, USA).

Table 1: Formula of film coating suspension for coating theophylline core tablets

Material (g)	Function	Concentration (g/100 ml) in		
		S1	S2	S3
Okra gum	Film former	0.62	1.20	3.00
Plasticizer	plasticizer	0.62	0.62	0.62
Titanium dioxide	Opacifier	1.00	1.00	1.00
Talcum powder	Antitacking	4.00	4.00	4.00
Water, q s	Dispersion medium	100	100	100

q.s: Quantity sufficient

Effect of storage conditions on the integrity of coated tablets

Coated theophylline tablets were exposed to relative humidity conditions between 11 and 85% RH in a desiccator and the effect of storage on the integrity of the coated tablets was investigated over a six-month period.

RESULTS

The rheological properties and NIR absorption spectra of samples of Okra gum

Off white powdered okra gum samples with loss on drying of 1.4-2.5% were obtained. The pH of a 2% w/v aqueous dispersion of K1, K2, K3, and K4 samples were 6.59 ± 0.003, 6.27 ± 0.003, 6.23 ± 0.000, and 6.23 ± 0.003, respectively. Figure 1 shows the nIR raw absorption spectra and its second derivative for the samples of okra gum. The absorption of K1, K2, and K3 samples at 1400 nm was respectively 0.265, 0.34087, and -0.021 while that of K4 was -0.085. The absorption increased with increase in wavelength. At 2300 nm, the nIR absorption spectrum was 0.696, 0.282, 0.240, and 0.125, respectively, for K1, K2, K3, and K4. The viscosities of a 2% w/v of okra samples at different shear rates are shown in Table 2. Sample K1 exhibited higher value of viscosity, torque, and shear stress

Table 2: Rheological properties of 2% w/w samples of okra gum used in the film coating operation

RPM	Viscosity of sample (cP)			
	K1	K2	K3	K4
10	179.75	92	84.25	66.52
20	138.25	88.3	71.5	54.59
25	134.5	78.75	67.25	52.08
30	123.5	75.75	64	48.69
40	106.5	71.5	59.75	44.93
50	98	68	55	41.67
75	84	61.75	48.5	37.65
100	75.25	57.25	43.75	33.01
125	71	53.75	40.75	30.12
150	65.25	49	38.25	25.10
175	60.75	43.25	36	22.72
200	54.75	37.75	34.25	19.95
250	45.5	33	31.5	18.45
200	55	37	34.25	20.08
175	61	42.25	36	22.84
150	65.5	49	38.25	25.10
125	71.25	53.75	40.75	29.99
100	75.25	57.25	44.25	32.50
75	84.75	61.75	49	36.52
50	99	68.25	56.25	42.17
40	109.5	71.75	60	44.93
30	120.75	75.75	64.5	48.82
25	134	78.75	68	52.33
20	141.75	81	72.5	54.72

RPM: Revolution per minute, cP: Centipoise

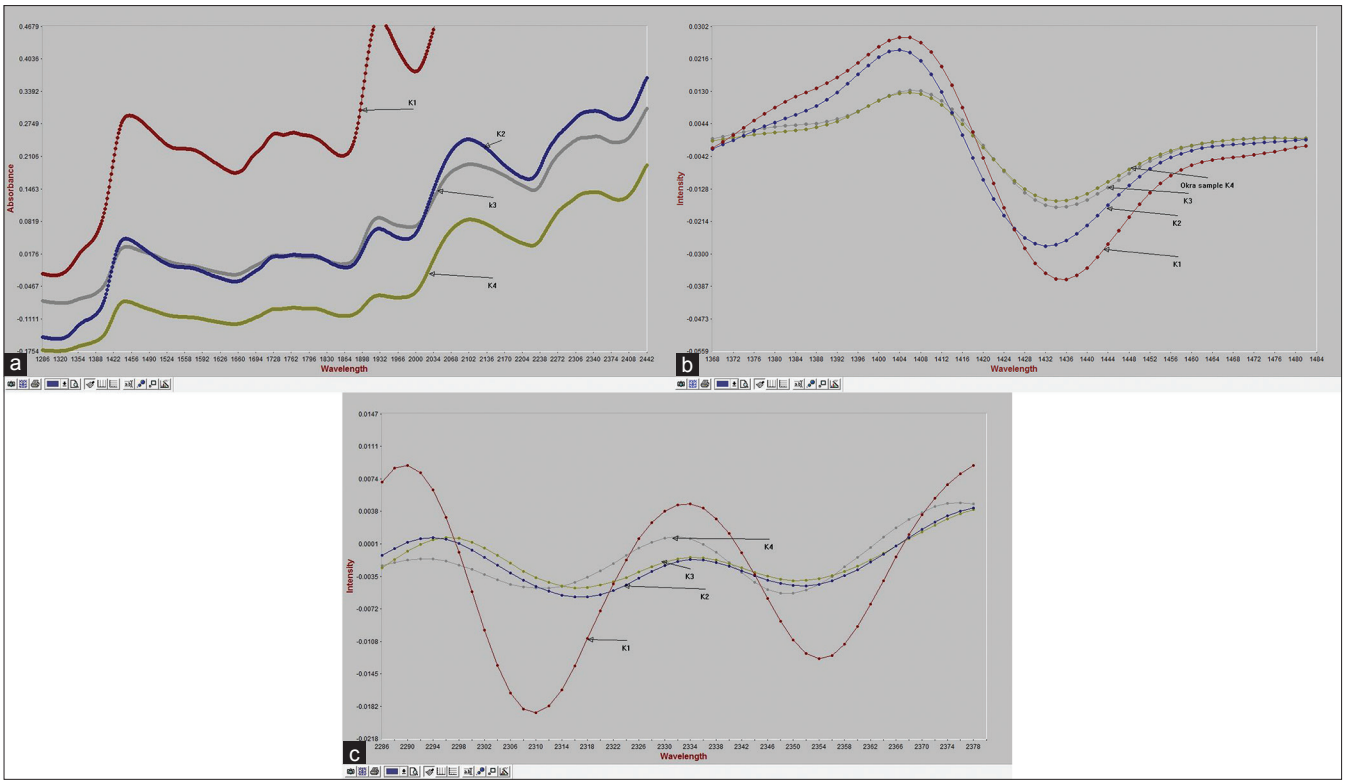

Figure 1: (a) Raw nIR spectra of samples of okra gum raw spectra (b) Second derivative nIR spectra of samples of okra gum at about 1400 nm (c) Second derivative nIR of samples of okra gum around 2300 nm

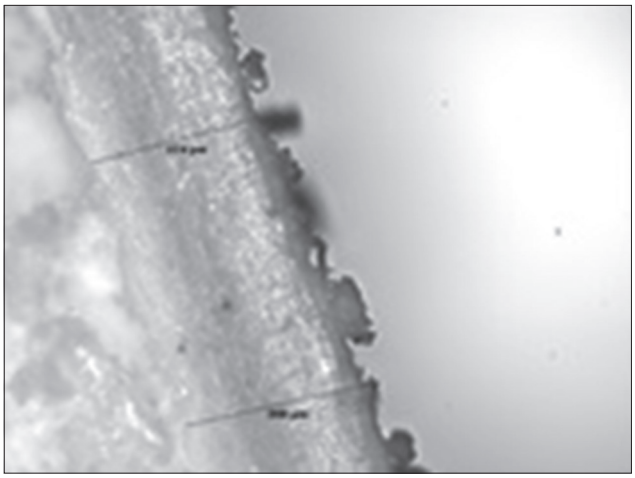

Figure 2: Photomicrograph of a typical film deposit on theophylline tablets

than the others and the viscosity was generally of the order: K1 >K2 >K3 >K4 at a given spindle speed.

Some physicochemical properties of batches of coated theophylline tablets

Some physical properties of coated theophylline tablets

The viscosity of a 0.62%w/v (S1) coating suspension was 33.04 ± 0.001-75.48 ± 0.003cP at 100 rpm. The coating suspension passed through the spray nozzles easily. The tubing and nozzles of the coating equipment were not blocked during the entire coating operation, irrespective of the okra gum sample used. Good coated theophylline tablets were obtained from the formulations due to the free flow of the coating suspension that led to the deposition of coating suspension droplets and the subsequent film formation on the substrate. The viscosity of coating suspension containing K1 at 1.2%w/v (S2) was 158.27 ± 0.008 cP and was too viscous to be pumped or sprayed through the nozzles of the spray gun to coat the tablets. The viscosity of the coating suspension (formulation S3) at 100 rpm was 83.6 ± 0.23, 80.8 ± 0.15, and 77.6 ± 0.22 cP, respectively, for samples K2, K3, and K4, and their pH was 7.30 ± 0.003. The coated tablets were glossy with firm and intact film that did not peel off when rubbed against a white paper background. Figure 2 shows the photomicrograph of a typical film deposit on theophylline tablet while some physicochemical properties of the coated theophylline tablets at this concentration are also shown in Table 3. The average weight of the coated tablets was between 270.6 ± 0.37 and 271.0 ± 0.33 mg for all the formulations. The hardness of the coated tablets was 6.54 ± 0.222, 6.24 ± 0.188, and 5.88 ± 0.036 kgf, respectively, for formulations K2, K3, and K4 while that of the core tablets was 5.72 ± 0.175 kgf. The disintegration time of the coated tablets was within 2 minutes, irrespective of the sample. Table 4a shows the statistical data on the hardness of the uncoated and coated theophylline tablets as well as those with the film thickness of samples of theophylline coated with the okra

Table 3: Some physicochemical properties of coated batches of theophylline tablets

Description	Samples of theophylline tablets coated with			
	K2	K3	K4	Core
Weight uniformity (mg)	271.0±0.33	270.9±0.35	271.2±0.40	270.6±0.37
Hardness (kgf)	6.54±0.222	6.24±0.188	271.2±0.40	270.6±0.37
Friability (%)	0	0	0	0
Disintegration time (min)	1.5±0.05	1.5±0.00	1.25±0.05	0.75±0.02
Diameter (mm)	10.42±0.003	10.36±0.005	10.39±0.003	10.33±0.002
Thickness (mm)	3.67±0.001	3.62±0.009	3.63±0.009	3.64±0.002
Film thickness (μm)	60.23±2.71	60.0±3.066	60.9±1.98	0

Table 4a: Statistical analysis of the hardness of theophylline (core and coated) tablets

	Variable 1	Variable 2
Mean	6.54	5.72
Variance	0.496	0.306
Observation	10	10
Pooled variance	0.401	
Hypothesized mean difference	0	
df	18	
t-stat	2.895	
P (*T*≤*t*) one tail	0.005	
t Critical one tail	1.73	
P (*T*≤*t*) two tail	0.01	
t Critical two tail	2.1	

gum samples. At (18) = 2.895, $P < 0.005$ was obtained for the independent analysis of the hardness of core and coated theophylline tablets. Table 4b shows that F = 3.798, DF = 29, $P < 0.035$ in the analysis of variance (ANOVA) of hardness of theophylline tablets coated with samples of okra gum. ANOVA on the film thickness during the coating and drying process of a batch of the coated theophylline tablets is presented in Table 4c while Table 4d shows that F = 0.039, DF = 29, $P < 0.96$ in the evaluation of the film thickness among batches of theophylline tablets after coating with novel samples of okra gum (3.0%w/v) at 3.0 ml/min for 100 minutes**.** Table 5 shows the effect of curing the coated tablets over a 60-minute period on some characteristics of the tablets. A value of t (18) = 0.617, $P < 0.272$ was obtained on the hardness of the coated tablets cured for 1 hour at 60°C while the t (18) =1.599, $P < 0.06$ with respect to the dimensions of the cured tablets in the one tail test with a t critical of 1.73 when the diameters of samples from curing at 30 minutes and 1 hour were compared. The average diameter of the coated tablets decreased from 10.42 mm (SD = 0.009) to 10.389 mm (SD = 0.015) after 1 hour of curing at 60°C. Similarly, the thickness of the tablets decreased from 3.665 mm (SD = 0.036) to 3.638 mm (SD = 0.025). The dissolution studies showed that a 100% release of theophylline was attained within 15 minutes, irrespective of the sample. The coated tablets stored at 11, 40, 50, and 75% RH absorbed and desorbed moisture from the environment within the first 24-48 hours but equilibrated thereafter for the next 6 months, absorbing about 0.02% w/w moisture. The moisture sorption during this period was double (0.04% w/w) at 85% RH.

NIR spectroscopy to demonstrate film coating with okra gum on theophylline tablets

Figure 3 shows both the raw and the second derivative nIR spectroscopy of talcum powder, titanium dioxide, core, and coated theophylline tablets. NIR prominent absorption of talcum powder occurs at 1396 and 2310 nm and the value is respectively -0.138 and 0.0126. Figure 4 shows both the raw and the second derivative nIR spectroscopy to demonstrate the deposition of film coating materials. The prominent absorptions of the coated tablets, corresponding to that of talcum powder, are 1400 and 2300 nm and are directly proportional to the film thickness.

Effect of concentration of coating suspension on the coating process

Coating operation was successful with K2, K3, and K4, but not with K1 samples when prepared based on S 1 formulation.

DISCUSSION

The different nIR absorption and pH profiles of okra gum samples are due to the influence of the extraction processes. Changes in viscosity of the gum were due to the elevated temperature in the presence of electrolyte and the centrifugation that weakened inter-particle bond and increased particles size distribution. It appears that longer treatment was required for a marked difference between K3 and K2.

The coated theophylline tablets have minimal weight variation (SE of 0.33 to 0.40) due to well-controlled coating processes. The movement of tablets within the moving bed, the regularity and scattering of tablet presences in the spray region, and the projected surface area of tablet that receive the spray can impact and control the amount of coat a tablet receives during a typical coating operation. The moderate pan speed and the presence of baffles helped in ensuring uniform opportunities and appearance of tablets at the spray zone.[22-24] The resemblance of the disintegration time profile of the coated to those of the core tablets was probably

Table 4b: Statistical analysis of the hardness of theophylline coated with novel samples of okra gum (3.0% w/v) at 3.0 ml/min for 100 minutes

Summary						
Group	**Count**		**Sum**		**Average**	**Variance**
K2	10		65.4		6.54	0.5
K3	10		62.4		6.24	0.35
K4	10		58.8		5.88	0.01
ANOVA						
Source of variation	**SS**	**DF**	**MS**	***F* value**	***P* value**	***F* critical**
Between group	2.184	2	1.09	3.797	0.035	3.35
Within groups	7.764	27	0.29			
Total	9.95	29				

ANOVA: Analysys of variance, SS: Sum of squares, DF: Number of degree of freedom, MS: Mean of squares

Table 4c: Film thickness during the coating and drying operation of a batch of theophylline tablets coated with a sample of okra gum

Summary						
Group	**Count**		**Sum**		**Average**	**Variance**
Coating 30 min	6		120		20	36
Coating 45 min	6		171		28.5	101.5
Coating 60 min	6		217		36.17	4.17
Coating 100 min	6		307		51.17	8.57
Drying 5 min	6		301		50.17	79.37
Drying 15 min	6		303		50.5	52.7
Drying 30 min	6		305		50.83	16.57
Drying 45 min	6		288		48	87.6
Drying 60 min	6		231		38.5	65.9
ANOVA						
Source of variation	**SS**	**DF**	**MS**	***F* value**	***P* value**	***F* critical**
Between group	6285.59	8	785.7	15.63	<0.05	2.15
Within groups	2261.83	45	50.26			
Total	8547.43	53				

ANOVA: Analysys of variance, SS: Sum of squares, DF: Number of degree of freedom, MS: Mean of squares

Table 4d: Statistical analysis of the film thickness from theophylline tablets coated with 3.0% w/v samples of okra gum for 100 minutes

Summary						
Group	**Count**		**Sum**		**Average**	**Variance**
S1	10		600		60	73.33
S2	10		600		60	94
S3	10		609		60.9	39.21
ANOVA						
Source of variation	**SS**	**DF**	**MS**	***F* value**	***P* value**	***F* critical**
Between group	5.4	2	2.7	0.039	0.96	3.354
Within groups	1858.9	27	68.85			
Total	1864.3	29				

ANOVA: Analysys of variance, SS: Sum of squares, DF: Number of degree of freedom, MS: Mean of squares

due to the hydrophilic nature of the polymer and could be of advantage in taste or odor masking and for similar reasons. The increases in the dimensions of coated tablets were due to film deposition. The t value obtained at $P = 0.05$ showed a significant difference between the hardness of the core and those of the coated theophylline tablets. The significant difference in the hardness of the samples at $P = 0.05$ suggests that the samples were not drawn from the same lot, providing further evidence to claim that the application of film coating on the core theophylline tablets with okra gum influenced the outcome. The ANOVA on the theophylline tablets suggested a statistical difference at

Table 5: Effect of curing on some physical properties of theophylline coated tablets

Description	Curing coated tablets for:				
	End of coat	5 min	30 min	I hour	Left in pan for 24 hour
Weight uniformity (mg)	271.3±0.35	271.0±0.06	270.2±0.55	270.2±0.4	272.0±0.75
Hardness (kgf)	6.54±0.22	6.69±0.21	6.57±0.18	6.51±0.22	5.5±0.23
Friability (%)	0	0	0	0	0
Disintegration time (min)	1.25±0.00	1.25±0.00	1.25±0.00	1.25±0.00	1.25±0.00
Tablet diameter (mm)	10.42±0.005	10.41±0.002	10.40±0.002	10.39±0.003	10.43±0.005
Tablet thickness (mm)	3.67±0.002	3.66±0.002	3,65±0.001	3.64±0.002	3.65±0.002
Film thickness (μ)	60.5±3.16	60.23±2.87	60.0±1.64	60.0±1.5	60.7±3.91

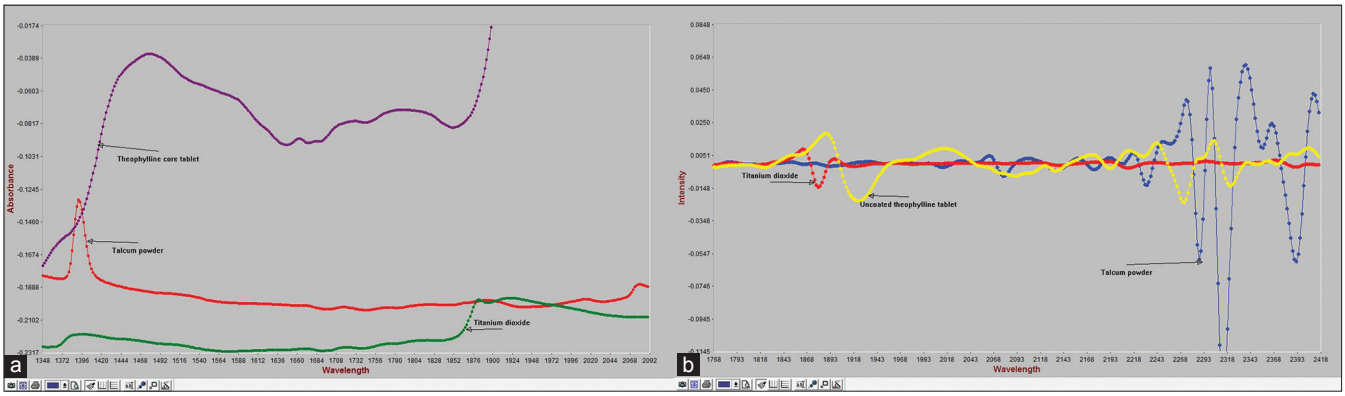

Figure 3: nIR spectra of coating materials used in the film coating (a) raw spectra (b) second derivative

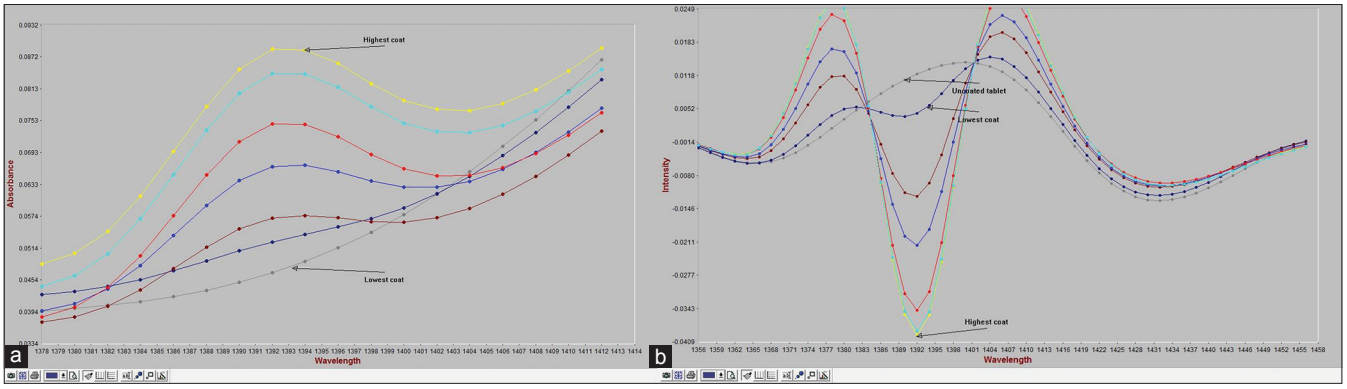

Figure 4: nIR spectra of coated theophylline tablets (a) raw spectra (b) second derivative showing levels of coating on substrate

$P = 0.05$ in the hardness but not with film thickness among samples of the tablets coated with K2, K3, or K4. The study also shows that the hardness of the coated tablets was not influenced by curing.

Tablets increased in their diameters and thicknesses as a function of the duration of coating operation. The adhesion of coating materials to the tablet was due to the presence of the film former, which provided the binding force necessary for adhesion. The results of the curing study indicated that there were changes in the thickness and diameter of the coated tablets depending on the curing duration. Further heat treatment facilitated the removal of moisture and the coalescence of the gum leading to a good coat on the tablet.

In-process assessment of the film deposit on the theophylline tablets and hence coating efficiency was possible with the nIR spectroscopy because talcum powder exhibited pronounced absorptions in the near infrared region. Second derivatives are mathematical treatment of the raw data to rule out differences that may arise from packing, noise, and sample particle size differences. Near infrared spectroscopy has great potential for improving the monitoring and control of industrial processes.

A low viscosity polymer provides a platform for more solids and a firm film within a short period of time compared to a highly viscous polymer in a film coating operation. Low viscosity okra gum samples obtained from the novel extraction method were used at high concentration as film formers requiring less coating time than would have been

possible with those from the traditional extraction process. All the okra samples provided a platform for film coating using the laboratory equipment without difficulties. There was no significant difference in the thickness of the film deposited on theophylline tablets with any of the three okra samples because at the polymer concentration of 3%w/v was within the viscosity range that can easily be handled by the laboratory coating equipment. Sample K4 might provide more solids than either K3 or K2 sample due to low viscosity and thereby reduce the coating duration. Although film coating is treated as a straightforward operation, the complexity of this unit operation may arise from the fact that multiple variables such as heat and mass transfer characteristics, the coating curing, the spray configuration, the nature of the coating material, the geometry of the system, the nature of the core, and the rate and extent of coating accumulation may influence the quality and degree of coating.

CONCLUSION

Samples of okra gum with low viscosity were obtained from the novel extraction process compared to those obtained from the traditional extraction method. These samples are useful film coating agents, delivering more solids at reduced coating time than is possible with products from the traditional method.

REFERENCES

1. Miller AD, Mcginity JW. Aqueous polymeric film coating. In: Augsburger LL, Hoag WS, Editors. Pharmaceutical dosage forms: Tablets Unit operations and mechanical properties. Unit operations and mechanical properties. 1. 3rd ed. New York: Informa Health Care; 2008. p. 638.
2. Cunningham C, Hansell J, Nuneviller F 3rd, Rajabi-Siahboomi AR. Evaluation of recent advances in continuous film coating processes. Drug Dev Ind Pharm 2010;36:227-33.
3. Cole G, Aulton ME, Hogan J. Pharmaceutical coating technology. NewYork: Informa Health Care; 1995. p. 504.
4. Hogan JE. Tablet coating. In: Aulton ME, Editor. Pharmaceutics: The science of dosage form design. New York: Churchhill Livingstone; 1988. p. 734.
5. Tavakoli N, Ghasemi N, Taimouri R, Hamishehkar H. Evaluation of okra gum as a binder in tablet dosage forms. Iranian J Pharm Res Supple 2004;2:47.
6. Momoh MA, Adikwu MU, Ogbona JI, Nwachi UE. *In vitro* study of release of metronidazole tablets prepared from okra gum, gelatin gum and their admixture. Bio-Res 2009;6:339.
7. Kalu VD, Odeniyi MA, Jaiyeoba KT. Matrix properties of a new plant gum in controlled drug delivery. Arch Pharm Res 2007;30:884-9.
8. Ogaji I. Some physicochemical properties of acetaminophen pediatric suspensions formulated with okra gums obtained from different extraction processes as suspending agent. Asian J Pharm 2011;5:15-20.
9. Attama AA, Adikwu MU, Amorha CJ. Release of indomethacin from bioadhesive tablets containing CarbopolÂ® 941 modified with Abelmuschus esculentus (Okra) gum. Boll Chim-Farm 2003;142:298.
10. Ogaji I, Nnoli O. Film coating potential of okra gum using paracetamol tablets as a model drug. Asian J Pharm 2010;4:130-4.
11. Tyler VE, Brady LR, Robers JE, editors. Plant Gums and Mucilage. 8th ed. Philadelphia: Lea and Febiger; 1981.
12. Kumar SV, Kala MS, Mohammed Saleem ST, Gauthaman K. Drug utilization and prescription monitoring of asthma patients. J Young Pharm 2009;1:180-3.
13. Amighi K, Moës A. Influence of plasticizer concnetration and storage conditions on the drug release rate from Eudragit RD 30 D film- coated sustained -release theophylline pellets. Eur J Pharm Biopharm 1996;42:29-35.
14. Bayraktar O, Malay O, Ozgarip Y, Batigun A. Silk fibroin as a novel coating material for controlled release of theophylline. Eur J Pharm Biopharm 2005;60:373-81.
15. Kucera S, Shah NH, Malick AW, Infeld MH, McGinity JW. Influence of an Acrylic Polymer Blend on the Physical Stability of Film-Coated Theophylline Pellets. AAPS Pharm Sci Tech 2009;10:864-71.
16. Lin WJ, Lee HG. Design of a microporous controlled delivery system for theophylline tablets. J Contr Release 2003;89:179-87.
17. McGinity JW, Cameron CG, Cuff GW. Controlled-release theophylline tablet formulations containing acrylic resins. i. dissolution properties of tablets. Drug Dev Ind Pharm 1983;9:57-68.
18. Nokhodchi A, Okwudarue ON, Valizadeh H, Momin MN. Cogrinding as a tool to produce sustained release behavior for theophylline particles containing magnesium stearate. AAPS Pharm Sci Tech 2009;10:1243-51.
19. Ogaji I, Hoag SW. Effect of grewia gum as a suspending agent on ibuprofen pediatric formulation. AAPS Pharm Sci Tech 2011;12:507-13.
20. Ogaji I. Application of grewia gum in film coating of theophylline hydrochloride tablets. Jos, Nigeria: University of Jos; 2012.
21. United States Pharmacopoeia/National Formulary. 32/27 ed. 12601, Twinbrook Parkway, Rockville, MD 200852: The United States Pharmacopoeia Convention; 2009. p. 1381.
22. Pandey P, Song Y, Turton R. Modeling of pan-coating processes for pharmaceutical dosage forms. In: Salaman AD, Hounslow MJ, Seville JPK, Editors. Granulation. Amsterdam: Elsevier; 2007.
23. Pandey P, Turton R. Movement of different shaped particles inside a pan coating device using novel video-imaging techniques. AAPS Pharm Sci Tech 2005;6:e237-44.
24. Pandey P, Song Y, Kahiyan F, Turton R. Simulation of particle movement in a pan coating device using discrete element modeling and its comparison with video-imaging experiments. Powder Technol 2006;161:79-88.

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