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PATTERN OF ANTHRAQUINONINE DERIVATIVES IN SOME *CASSIA* SPECIES: A QUALITATIVE AND QUANTITATIVE ESTIMATION

Vinay Pandit, MS Ashawat and CPS Verma*

Laureate Institute of Pharmacy, Kathog, Jawalaji, Kangra.

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***Corresponding Author**
CPS Verma
Laureate Institute of Pharmacy, Kathog, Jawalaji, Kangra.

ABSTRACT

A study of qualitative and quantitative estimation of anthraquinone glycosides in *Cassia occidentalis, Cassia surratensis* and Cassia tora has been carried out. The determination of Rf values, UV- maxima and melting point helped the correct identification of free anthraquinone derivatives. They were tested for their presence by carrying out the extraction of the materials in soxhlet apparatus with chloroform and the extractives were subjected to borntrager's test. The various parts of *Cassia occidentalis* showed the presence of chrysophanol, aloe-emodin, emodin, physcion, and an unknown components as major components in a decreasing order. Different methods and investigation have been done for the estimation of total percentage of glycosidic aglycone and found almost same. The results on being compared with earlier findings showed marked variations. The variability could be attributed to the change in the chemical composition of the phenotype and genotype and the method adopted for isolation, identification and quantitative estimation of these compounds. The distribution of anthracene derivatives in the cassia species investigated so far show a very unsystematic and ambiguous pattern of these derivatives and that could be the reason why many chemo taxonomists are of the opinion that anthraquinone derivatives cannot be the basis for chemotaxonomical classification of cassia species. But looking into the work reported on these species it is observed that no systematic work has been carried out to look into the occurrence of anthraquinone derivatives in all parts of *Cassia* species at one time using the identical methods of analysis. However, it is opinioned that if a systematic study as was undertaken in the present investigation is carried out, we might come to a conclusion for establishing a definite chemo taxonomical classification of cassia species.

KEYWORDS: Anthraquinone; glycosidic aglycone; phenotype; genotype.

INTRODUCTION

Various natural products have been identified from different plant species and all of having their own biological and medicinal importance. Compounds isolated from number of plant species have a **lead** compound for additional search. Anthraquinones isolated from *Cassia* species are one of such compounds which are having great importance in such fields and serve as basic skelton. Genus *Cassia* in family leguminoseae(sub- family Casealpinaceae) comparises of about 500 species. Out of these 23 species occur in India. Anthraquinones are functionally diverse compounds related to anthracene. In present study, anthraquinones derivatives in medicinal plants are studied in various forms at different oxidative levels and derivatives of anthraquinone, anthrone, oxanthrone and anthranol as well as in a dimeric form (dianthrone). Also these anthracene derivatives occur in the free form. The anthraquinone derivatives have been used effectively as cathartic agents. The action is due to their anthracene constituent acting on the large intestine. When these constituents are present in the plants as glycosides e.g. sennosides, the sugar help to transport the anthracene aglycone interact to large intestine where the aglycone is liberated by the enzymes. The trival or generic names of anthracene derivatives and their structures may also be described as per figure 1. The glycosides are generally only very slightly soluble in water, but are more soluble in ethanol, methanol, or mixture of water with ethanol or methanol. The presence or absence of different polarity Contributing functional groups in the structure of the aglycone portions of a glycoside contribute to the degree of solubility in a given solvent. The initial extraction procedures for inactivation of enzymes (the glycosidase) in many cases,is necessary before or during the extraction of glycosides. The inactivation may be carried out by (a) the fresh or dry plant materials boiled with water or alcohol for about 10-20 minutes (inactivating the enzymes and extracting the glycosides (b) the plant materials boiled with acetone (c) the plant material is treated with acid at pH 1-2 at cold temperature and carried out initial extraction at a very low temperature. The anthraquinone glycosides have been found to be present in lower as well as higher plants. Some of them have been isolated from angiosperms, fungi, and lichens but they don't occur in bryophytes, gymnosperms and pteridophytes. The anthracene compounds also occur as aglycone of O-glycosides and in other cases as aglycone of C-glycosides. The genus cassia comprise of about 500 species are ether herbs, shrubs or trees, most of them are of medicinal value, a few providing tannin materials of economic values. They are widely distributed in the tropics, but a few in extra tropics.

Different forms of anthracene derivatives possess different degree of activity. Those with two phenolic hydroxyl groups are active while those with one phenolic hydroxyl group are not active and that removal or acetylation of the phenolic group in these anthracene derivatives leads to loss of cathartic action. However, most of the cassia species, exhibit cathartic agents.

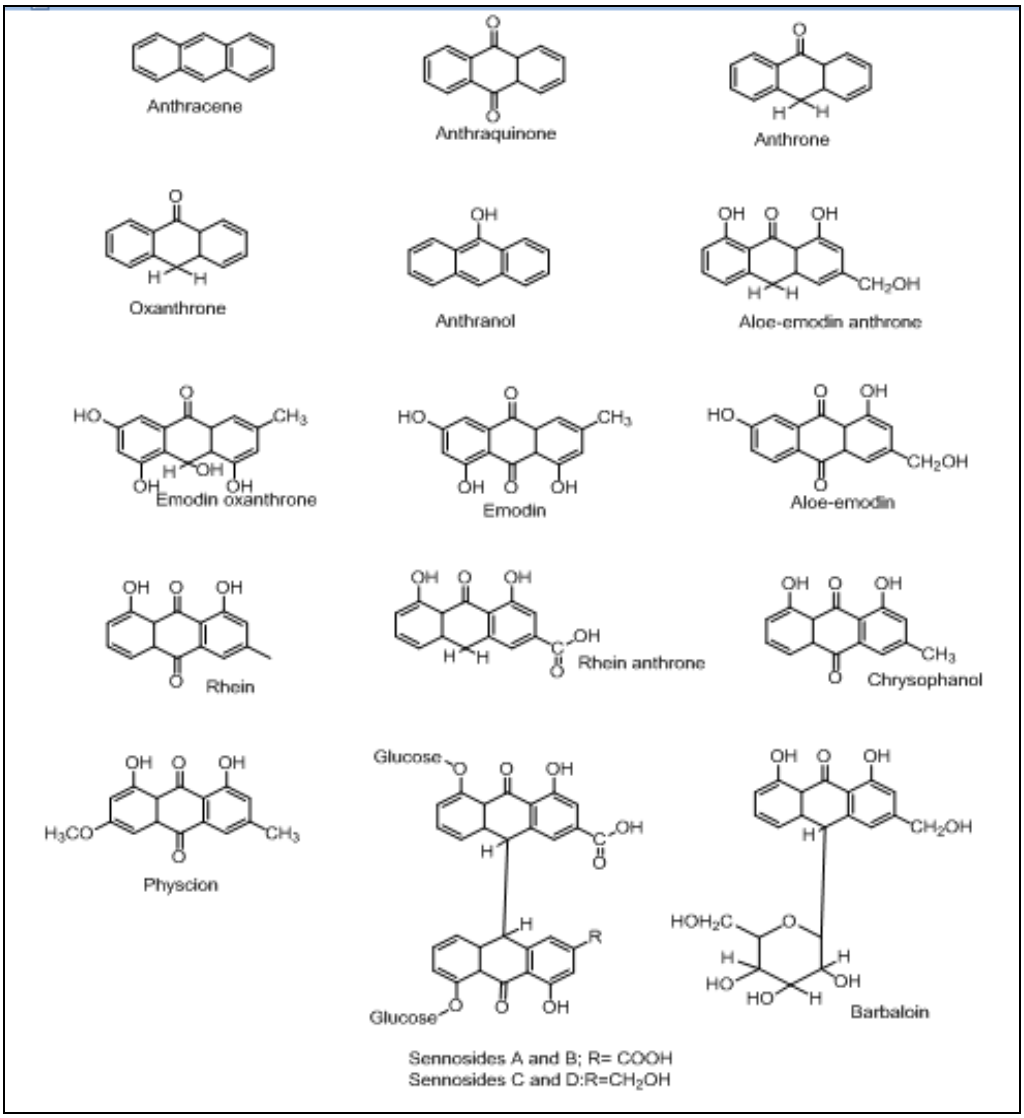

Figure 1: Trival names of anthracene derivatives and their structures

Cassia occidentalis linn

Cassia occidentalis (syn.occidentalis) in different regions is known by different vernacular names,which are kasondi,barikasondi or kasunda-hindi, kalkasunda–bengali,natram-iakarais,peya-veri-Tamil,kashinda –Telgu, kasundro-gujarati. The seeds of cassia occidentalis are used for wintercough, as a cure for convulsions in children, as an excellent diuretic, as a purgative, as atonic and febrifuge and has been found to relieve the spasm and expel wind

accumulated in the intestine of dyspeptic nervous patients. The whole plant is used as purgative.

Cassia surattensis linn

Cassia surattensis (synonym, C. glauca, C.fastiguata) in different regions is known by different vernacular names: which are kondatanteputacheu-Telgu, Weillia tagera–malayalam. It is found to be Himalaya and other places in india. A large shrub or small tree,with spreading, grooved more or less glabrous branches.*Cassia surattensis* leaves and barks are prescribed in diabetes and gonnoarhea.

Cassia tora

Syn. (cassia toroides roxb, cassia foetida, cassia obtusifolia linn).

It is known by different vernacular names as English Foetid cassia, gujarati-koyaraya,hindi and Bengali-chakunda, panevar), Malayalam-Takara, Marathi-(Tankali, takla),Tamil-Tagarai-tagirisa. It has great reputation in all kinds of skin diseases.

Numerous methods have been reported for estimation of anthraquinone derivatives in senna leaf and pod. Most of these are colorimetric assays based on the well-known borntrager's test. The drug is powdered, hydrolysed and aglycones liberated are extracted with immisicible solvents such as ether, chloroform which is then extracted with a solution of an alkali. The intensity of Pink or red colour developed in alkaline solution is compared with that of the standard solution. In the present investigation an attempt has been done to isolate and estimate the anthraquinone derivatives that occur in various parts of these species. Also looking into chemo taxonomical aspect of the cassia species, it was thought worth while to look into the pattern of anthraquinone derivatives in these species so that all species which come under this particular genera may be put into appropriate group of chemotaxonomic classification.

Moreover, it was also observed that no scientific investigation have been carried out on cassia surattensis. In the present study, the pattern of anthraquinone derivatives have been undertaken for the first time.

MATERIAL AND METHODS

Different parts of *Cassia occidentalis* and Cassia *tora* were collected from fields of village jonapur New Delhi, while the different parts if *Cassia surratensis* were collected from the

institute of history of medicine and medical research campus, New Delhi, during 1983 to December 1983.

The reagents used in the present investigation were of anal grade from B.D.H. and I.D.P.I. The authentic sample of antharquinone were procured from the instituite of pharmaceutical biology and phytochemistry, westf. wilhelms universitat, munster, west Germany, the department of pharmaceutical sciences, Nagpur and authentic samples of sennosides A and sennoside B were provided by Sandoz laboratories, basel, Switzerland.

The pattern of anthraquinone derivatives in various parts viz. flowers, leaves, roots, pods (without seeds), stems and seeds of *Cassia occidentalis, Cassia surattensis,* and *Cassia tora* were studied and accordingly all the authentical materials were procured.

Chemical test for the detection of Anthraquinone derivatives (Borntrager 'test)

The plants materials were subjected to the chemical test for the detection of anthraquinone derivatives.100 mg of powdered plant parts dried at 60° C were seperately taken in a test tube and boiled with 10ml of chloroform. The chloroform layers were separated by filtration and it to 10% ammonia solution were added. The ammmonical layer showed distinctly pink or red colour in all the test tube indicating the presence of anthraquinonine various parts of *C.occidentalis*, *C.surattensis* and *C.tora* except in case of root and pod of *C.tora*.

The presence of anthraquinone glycosides were detected by taking the powders materials, which were devoid of free anthraquinone were oxidatively hydrolyzed with 10% w/v ferric chloride and hydrochloric acid solution. The mixture were boiled for 20 minutes and filtered while hot were then extracted with chloroform. The chloroform layers were seperated and tested as above. In these experiments also the ammmonical layers acquired a pink or red colour indicating the presence of anthraquinone glycosides in all parts of *C.occidentalis, C.surattensis and C.tora*.

Separation of free Aglycones by Thin Layer Chromatography

The free aglycones were extracted with chloroform and were concentrated to 5 ml and were subjected to thin layer chromatography using rhein, physcion, emodin, chrysophanol, and aloe-emodin, as authentic reference samples. The TLC plates were coated with silica gel G, by using a slurry of 30 gm of silica gel G with 60 ml of water. The plates were first air dried at room temperature and then activated at 110°C. The spots of test extracts along with

authentic samples were applied on the plates. The chromatograms were developed in the following solvent systems.

1. Benzene: ethyl formate: formic acid (74:24:1)
2. Benzene: carbon tetrachloride (1:1)
3. Benzene: glacialacetic acid(8:2)
4. Petroleum ether (40°-60°): ethyl acetate: glacial acetic acid(90:10:6)

The chromatograms were developed in the above solvent system. After removal of the plates from the chamber, they were dried and sprayed with 10%w/v methanolic potassium hydroxide solution. The plates were kept in an oven at 120°C for 25 minutes. The thin layer chromatographic results of the chloroform extracts of various parts of *Cassis occidentalis, Cassia surattensis, Cassia tora* respectively in the solvent system. Table 1(A),(B),(C) show the presence or absence of free anthraquinone derivatives in various parts of *Cassis occidentalis, Cassia surattensis,Cassia tora* respectively. The pattern of antraquinone derivatives in various parts viz. flowers leaves roots, pods (without seeds), stems and seeds of *Cassia occidentalis*, *c. surattensis* and *C. tora* were studied and all authentically materials were procured. Positive **(+)** and negative **(–)** signs indicate the presence and absence of anthracene derivatives respectively.

1. **Table (A): Free Anthraquinone Derivatives in various Parts of *Cassia occidentalis* linn.**

Plant part	Rhein	Physcion	Emodin	Chrysophano1	Aloe-emodin	Unknown
Flowers	-	+	+	-	-	-
Leaves	+	-	+	+	+	-
Roots	-	+	+	+	-	-
Pods(without seeds)	-	-	-	-	+	-
Stems	-	-	-	+	-	+
Seeds	+	+	-	+	+	-

2. **Table (B): Free Anthraquinone Derivatives in various Parts of *Cassia surattensis*.**

Plant part	Rhein	Physcion	Emodin	Chrysophano1	Aloe-emodin	Unknown
Flowers	-	+	+	+	-	+
Leaves	+	-	+	-	+	-
Roots	-	-	-	+	-	+
Pods (without seeds)	-	-	-	+	-	-
Stems	-	-	-	+	-	-
Seeds	-	+	+	+	+	-

3. Table (C): Free Anthraquinone Derivatives in various Parts of *Cassia tora* linn.

Plant part	Rhein	Physcion	Emodin	Chrysophano1	Aloe-emodin	Unknown
Flowers	-	-	-	+	+	+
Leaves	+	-	+	-	-	+
Roots	-	-	-	-	-	-
Pods(without seeds)	-	-	-	-	-	-
Stems	-	-	-	-	-	-
Seeds	+	+	+	+	+	-

Isolation and Identification of Free Anthraquinones

For the isolation and identification of the free anthraquinones preparative thin layer chromatographic technique was used i.e. the preparative TLC plates were used and concentrated chloroform extracts of various parts of *Cassia occidentalis, Cassia surratensis* and *Cassia tora* together with the authentic samples were applied and from the unsprayed plate portions of the spot areas of separated compounds were scrapped.

These scrapped silica gel G portions were taken in the 10 ml centrifuge tubes and 5 ml portion of methanol (UV spectroscopic grade) were added and centrifuged for 10 minutes at 2000 rpm. UV maxima of the metahanolic extracts were determined. Table 2(A),(B),(C) show the Rf values, UV maxima and melting points of the compounds obtained from the *Cassia occidentalis, Cassia surattensis*and *Cassia tora* respectively.

Table1: (B) Thin layer chromatographic examination of the chloroform extract showing the result of various parts of *Cassia occidentalis* linn.

Compound	Colour in day light	Observed meth-anolic (10%w/v) Before heating	KOH spray Aftter heating	Rf (x100) System				UV maxima (nm)	Melting point
				1	2	3	4		
Rhein	Yellow	Pink	Pink	57.5	-	81	84	228,260,430	320-321*c
Physcion	Yellow	Pink	Pink	93.9	15	93	92	225,254,267,269,435	202*c
Emodin	Yellow	Pink	Pink	71	-	74	76	223,254,262,290,438	250-252*c
Cheyso-phanol	Yellow	Pink	Yellow	95.6	18	94	95	225,254,279,290,430	199-200*c
Aloe-emodin	Yellow	Reddish brown	Yellow	43	-	65	68	224,260,280,285,432 218,256,408,	222-223*c 310-311*c
Unknown	Yellow	Yellow	Yellow	58	-	-	82	438	

Solvent system:

1. Benzene : Ethyl formate : formic acid (74:24:1)
2. Benzene: Carbon tetrachloride(1:1)
3. Petroleum ether (40-60*c):Ethyl acetate : Glacial acetic acid (90:10:6)
4. Benzene : Glacial acetic acid (8:2)

Table 2(B): Thin layer chromatographic examination of the chloroform extract showing the result of various parts of *Cassia surratensis* linn.

Compound	Colour in day light	Observed meth-anolic (10%w/v) Before heating	KOH spray After heating	Rf (x100) System				UVmaxima (nm)	Melting point
				1	2	3	4		
Rhein	Yellow	Pink	Pink	58.2	-	80	84	228,260,432	320-321*c
Physicon	Yellow	Yellow	Pink	93.1	16	94	93	225,254,265,435	201-202*c
Emodin	Yellow	Pink	Pink	70	-	72	74	225,250,262,290,438	250-252*c
Cheyso-phanol	Yellow	Yellow	Pink	95.6	18	94	93	225,254,280,292,430	200-201*c

Aloe-emodin	Yellow	Yellow	Yellow	48.8	-	65	68	224,260,280,285,432	222-223*c
Unknown	Green	Yellow	Yellow	-	28	-	-	200,215,370,438	185-186*c

Solvent system:

1. Benzene : Ethyl formate : formic acid (74:24:1)
2. Benzene: Carbon tetrachloride(1:1)
3. Petroleum ether (40-60*c):Ethyl acetate : Glacial acetic acid (90:10:6)
4. Benzene : Glacial acetic acid (8:2)

Table 3(B): Thin layer chromatographic examination of the chloroform extract showing the result of various parts of *Cassia tora* linn.

Compound	**Colour in day light**	**Observed meth-anolic (10%w/v) Before heating**	**KOH spray Aftter heating**	**Rf (x100) System**				**Uv maxima (nm)**	**Melting point**
				1	**2**	**3**	**4**		
Rhein	Yellow	Pink	Pink	58	-	80	82	228,260,432	320-321*c
Physicon	Yellow	Pink	Pink	93	16	93	92	225,254,265,435	200-201*c
Emodin	Yellow	Yellow	Yellow	72	-	75	77	225,254,290,438	252-254*c
Cheyso-phanol	Yellow	Yellow	Pink	95	20	95	95	225,254,280,430	198-199*c
Aloe-emodin	Yellow	Pink	Pink	49	-	67	70	225,260,280,285,432	222-223*c
Unknown	Green	Yellow	Yellow	-	-	68	-	225,290,320,436	270-271*c

Solvent system:

1. Benzene : Ethyl formate : formic acid (74:24:1)
2. Benzene: Carbon tetrachloride(1:1)
3. Petroleum ether (40-60*c):Ethyl acetate : Glacial acetic acid (90:10:6)
4. Benzene : Glacial acetic acid (8:2)

Quantitative estimation

The plants were completely extracted with chloroform in soxhlet apparatus. 50 microlitres of these test extracts along with the standard samples were applied on silica gel G plates and developed in benzene, ethyl formate,formic acid (74:24:1). The spots were scraped and eluted in 10 ml spectroscopic grade methanol and the absorbance of rhein, physcion, emodin, chrysophanol and aloe emodin were determined at 230 nm,254 nm ,255 nm, 258 nm, 260nm respectively, while absorbance of unknowns were determined in terms of rhein i.e. at 230 nm. By the method of Fairbarin (1972) the amount of constitutents were determined by using known extinction coefficients. Table 3 (A),(B),(C) show the results for *Cassia occidentalis, Cassia surattensis* and *Cassia tora* respectively.

Table 3(A): The percentage of free anthraquinone derivatives in various parts of *Cassia occidentalis* linn.

	Percentage in dry weight						
	Rhein	**Physcion**	**Emodin**	**chrysophanol**	**Aloe-emodin**	**unknown**	**Total**
Flowers	-	0.0978	0.0664	-	-	-	0.1642
Leaves	0.0886	-	0.1182	0.0498	0.0583	-	0.3149
Roots	-	0.0687	0.0458	0.0589	-	-	0.1734
Pods (without seeds)	-	-	-	-	0.0320	-	0.0320
Stems	-	-	-	0.0234	-	0.0274	0.0508
Seeds	0.0568	0.1181	-	0.0986	0.0986	-	0.3721
Total	0.1454	0.2846	0.2304	0.2307	0.1889	0.0274	1.1074

Table 3(B): The percentage of free anthraquinone derivatives in various parts of *Cassia surattensis* linn.

	Percentage in dry weight						
	Rhein	**Physcion**	**Emodin**	**chrysophanol**	**Aloe-emodin**	**unknown**	**Total**
Flowers	-	0.0542	0.0290	0.0585	-	0.0202	0.1619
Leaves	0.05665	-	0.0571	-	0.0229	-	0.1365
Roots	-	-	-	0.0532	-	0.0210	0.0742
Pods (without seeds)	-	-	-	0.0098	-	-	0.0098
Stems	-	-	-	0.0209	-	-	0.0209
Seeds	-	0.1165	0.0312	0.1198	0.0548	-	0.3223
Total	0.0565	0.1707	0.1173	0.2622	0.0777	0.0412	0.7256

Table 3(C): The percentage of free anthraquinone derivatives in various parts of *Cassia tora* linn.

Percentage in dry weight							
	Rhein	**Physcion**	**Emodin**	**chrysophanol**	**Aloe-emodin**	**unknown**	**Total**
Flowers	-	-	-	-	0.0192	0.0570	0.0762
Leaves	0.1162	-	0.1190	-	-	0.0420	0.2772
Roots	-	-	-	-	-	-	-
Pods (without seeds)	-	-	-	-	-	-	-
Stems	-	-	-	0.0455	-	-	0.0455
seeds	0.0584	0.1109	0.0696	0.1184	0.0868	-	0.4441
Total	0.1746	0.1109	0.1886	0.1639	0.1060	0.0990	0.8430

GLYCOSIDES

Estimation of total glycosidic aglycones in various parts of *Cassia occidentalis, Cassia surattensis, Cassia tora*

Total glycosidic aglycones were estimated by the method described by Lemli (1965).the powdered (sieve no. 44) plant oarts (100 mg) were taken in 100ml conical flask with ground glasss joints. 20 ml of water was added and the flask were weighed. A condenser was attached and warmed for 15 minutes on the water bath. The flask was then cooled and weighed.

To adjust the original weights water was added. The solution was then centrifuged. 10 ml of this solution was transfeered to the round bottom flask with ground joints and to this 20 ml of the 10 % aqueous ferric chloride solution was added. The condenser was attached and the flask was heated for 20 minutes on the boiling water bath. In the flask then 1 ml of concentrated hydrochloric acid was added and the flask shaken well together with continuous heating for 20 minutes. The flask was cooled and the solution was transferred to a separating funnel Quantitatively. The solution was then extracted with three portion each of 25 ml ether. These extracts were combined. In this manner different plant parts of *Cassia occidentalis, Cassia surrattensis* and *Cassia tora* were treated for quantitative estimation.

These ether portions were transferred to volumetric flask (100 ml) and volumes were made upto 100 ml with ether. 10ml of these solutions were taken and evaporated. 10 ml of 1 N Potassium hydroxide solutions were added to dissolve the residues. Absorbance of these solutions were measured of Baush and Lomb Spectronic “21” Spectrophotometer at 488 nm, in 1 cm cell using 1N Potassium hydroxide as blank.

The percentage of total glycosidic aglycones present were determined by making use of standard curve of 1:8 dihyroxyanthraquinone (figure 1). Table 4(A),(B),(C). show the percentage if the total glycosidic aglycones in the various parts of *Cassia occidentalis, Cassia surrattensis* and *Cassia tora* respectively.

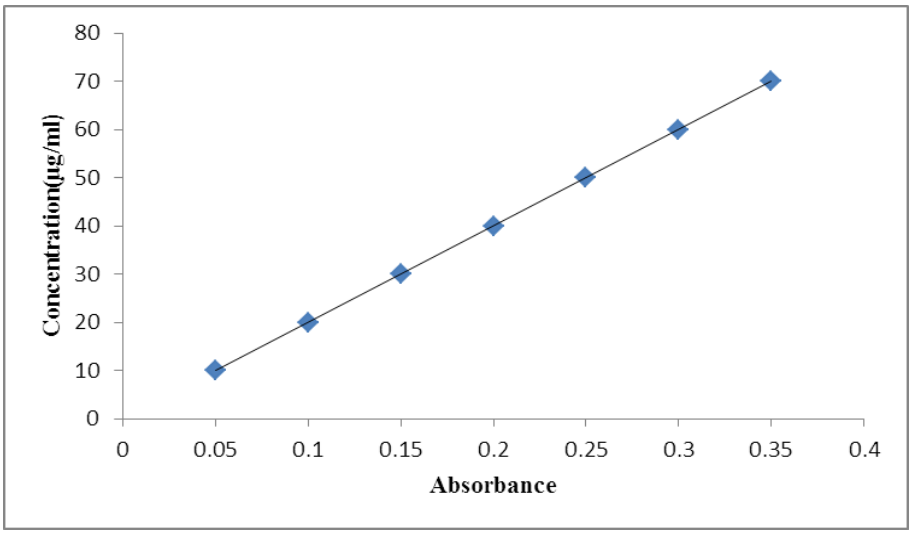

Figure 1: Standard curve of 1:8 Dihydroxy Anthraquinone

Table: 4(A) The percentage of total glycosidic aglycones in various parts of *Cassia occidentalis* linn.

Plant part	Time of collection	Borntrager's test	Absorbance in 1N KOH of dried ether ext.	Amount		Percentage constituents
				Per ml of ext. (µg)	Per 100mg of drug (mg)	
Flowers	July 83	+	0.038	1.2	024	0.2400
Leaves	July 83	+	0.101	3.2	0.6	0.6400
Roots	Aug. 83	+	0.021	0.63	0.126	0.1260
Pods (without seeds)	Aug. 83	+	0.017	0.54	0.10	0.1000
Stems	July 83	+	0.022	0.70	0.14	0.1400
Seeds	Aug.83	+	0.053	1.7	0.34	0.3400

Table 4(B): The percentage of total glycosidic aglycones in various parts of *Cassiasurattensis* linn.

Plant part	Time of collection	Borntrager 's test	Absorbance in 1N KOH of dried ether ext.	Amount		Percentage constituents
				Per ml of ext. (µg)	Per 100mg of drug (mg)	
Flowers	July 83	+	0.047	1.50	0.30	0.3000
Leaves	June-July 83	+	0.068	2.15	0.43	0.4300
Roots	Dec. 83	+	0.016	0.60	0.12	0.1200
Pods (without seeds)		+	0.009	0.28	0.056	0.0560
Stems	Dec. 83	+	0.021	0.65	0.13	0.1300
Seeds	Aug 83 Aug.83	+	0.058	1.8	0.36	0.3600

Table 4(C): The percentage of total glycosidic aglycones in various parts of *Cassia tora* linn.

Plant part	Time of collection	Borntrager 's test	Absorbance in 1N KOH of dried eiter ext.	Amount		Percentage constituents
				Per ml of ext. (µg)	Per 100mg of drug (mg)	
Flowers	July 83	+	0.042	1.3	0.26	0.2600
Leaves	July 83	+	0.102	3.2	0.64	0.6400
Roots	Aug. 83	-	0.026	0.80	0.16	0.1600
Pods (without seeds)	Sept. 83	+	0.010	0.032	0.064	0.0640
Stems	Aug 83	+	0.014	0.58	0.116	0.1160
Seeds	Oct.83	+	0.052	1.7	0.34	0.3400

O-glycosides

5 gm of the powdered plant materials devoid of free anthraquinones were extracted with distilled water and the final volumes were adjusted to 50ml. 20 ml of the extracts were taken and hydrolysed with 1N hydrochloric acid for 20 minutes in a boling water bath.

These were then extracted with chloroform. The chloroform extracts were combined and reduced to a small volume under vaccume. The authentic samples of rhein, physcion, emodin chrysophanol and aloe emodin together with the extracts were applied on silica gel G plates and the chromatograms were developed in the solvent system 1.

The developed chromatograms were sprayed with 10%w/v methanolic potassium hydroxide. For the identification of the O-glycosidic aglycones their UV maxima were determined.

Separation of O-Glycosidal mixtures

Glycosidal mixtures were separated by using the paper chromatographic method of Betts et al. (1958). The solvent system was prepared by shaking the mixtures of water:acetone:benzene (2:1:4) and then separated the two immisicible layers. The running solvent (the lower aqueous layer) was placed at bottom of the chromatographic chambers and in the corners of the chamber were placed beakers containing the upper layer. chambers were allowed to come to equilibrium overnight. On chromatographic papers whatman no. 1 were applied the spots of the glycosidal mixtures (aqueous extract) of all the parts to be investigated. The papers were placed in the chromatographic chamber. The chromatograms were developed in the above mentioned solvent system and the papar chromatograms were sprayed with 0.5 % magnesium acetate in methanol and heated at 100° C for 3-5 minutes. Separated glycosides from glycosidal mixtures of various parts of *cassia occidentalis cassia*

surattensis and cassia tora. The chromatograms show that the glycosidal mixtures consisted of 4-glycosides which were designated as compound 1,2,3,4(Table 5 (A).(B),(C).

Table 5(A): the different glycosides from various parts of *Cassia occidentalis* linn.

Plant part	Compound no.	Colour observed in Methanolic mg.Acetate soln. (0.5%w/v) spray			Rf(x100) system 1	Uv maxima
		In day light	Before heating	After heating		
Flowers	1 2 3	Yellow brown Yellow Reddish brown	Yellow Yellow Brown	Yellow brown Yellow brown	26.4 56.1 94.6	208,275,490 238,340,410 220,338,430
Leaves	1s 2	Yellow Yellow	Yellow Brown	Yellow Brown	18.2 95.9	210,280,396 338,342,430
Roots	1 2	Yellow Yellow	Yellow Yellow	Yellow Yellow	39.1 57.4	216,270,340 330,356,430
Pods (without seeds)	-	-	-	-	-	-
Stems	1 2	Yellow Reddish brown	Yellow Reddish brown	Yellow Reddish brown	33.7 56.0	208,275,380 230,342,410
Seeds	1 2 3	Yellow Yellow Yellow	Yellow Yellow Yellow	Yellow Yellow Yellow	17.4 37.8 56.0	210,290,380 230,342,412 288,380,480

Table 5(B): the different glycosides from various parts of *Cassia suratensis* linn.

Plant part	Compound no.	Colour observed in Methanolic mg.Acetate soln. (0.5%w/v) spray			Rf(x100) system 1	Uv maxima
		In day light	Before heating	After heating		
Flowers	1 2	Yellow Yellow brown	Yellow Yellow Brown	Yellow brown Yellow Brown	9.5 96.6	216,290,492 240,344,416
Leaves	1 2 3	Yellow Reddish brown Yellow	Yellow Reddish brown Yellow	Yellow Reddish brown Yellow	6.8 42.6 87.2	220,360,438 230,365,416 290,380,490
Roots	1	Yellow	Yellow	Yellow	6.89	228,300,420
Pods (without seeds)	1	Yellow	Brown	Brown	6.8	216,310,436
Stems	1 2	Yellow Brown	Yellow Brown	Yellow Brown	6.8 68.9	216,288,490 220,290,410
Seeds	1 2 3 4	Yellow Brown Yellow Yellow	Yellow Brown Yellow Pale Yellow	Yellow Brown Yellow Yellow	8.1 43.2 70.3 96.6	312,356,492 250,280,410 416,456,482 240,340,416

Table: 5(C) the different glycosides from various parts of *Cassia tora* linn.

Plant part	Compound no.	Colour observed in Methanolic mg.Acetate soln. (0.5%w/v) spray			Rf(x100) system 1	Uv maxima
		In day light	Before heating	After heating		
Flowers	1 2	Yellow Yellow	Brown Yellow	Brown Yellow	25.7 92.6	214,280,490 230,342,410
Leaves	1 2 3	Red Yellow Yellow brown	Brown Yellow Yellow	Brown Yellow Yellow	11.5 62.8 93.9	220,280,430 220,356,438 288,380,480
Roots	1	Yellow	Yellow	Yellow	24.3	228,290,420
Stems	1	Reddish brown	Brown	Brown	23.6	216,286,485
Seeds	1 2 3 4	Pale Yellow Yellow Yellow Reddish brown	Yellow Yellow Yellow Brown	Yellow Yellow Yellow Brown	10.8 25.0 64.9 93.2	310,345,390 280,492 416,452,487 234,290,412

Identification of glycoside

The glycosides as compound 1,2,3 and 4 were identified by finding out their aglycone component,sugar and UV maxima. The glycosides were hydrolyzed with acid and the identification of sugars were performed. The individual glycosides were refluxed for 20minutes with 1N hydrochloric acid in a boiling water bath and extracted with chloroform and the aqueous layer were preserved for identification of sugars. The chloroform extracts were concentrated and applied on silica gel G plates with the authentic samples of rhein,physcion, emodin, chrysophanol and aloe emodin and the chromatograms were developed in the solvent system 1.2.3 and 4. The spots were scraped and eluted with methanol. By using the Baush and Lomb's spectronuc "21", spectrophotometer, the UV maxima of the eluted compounds were determined. Table 6 (A), (B), (C) show the glycosidic aglycones of the individual glycosides of the various parts of *C. occidentalis, C. surattensis, C. tora* along with their UV maxima and Rf values.

TABLE 6(A): The aglycone components of glycosides from various parts of *Cassia occidentalis.*

Compound no.	Aglycone component	UV maxima	(in nm) In methanol	Rf(x100)System 1	2	3	4	S.C.	Rf(x100)System Is	2s	3s
Flowers	1	Physcion	225,250,268,435	94	16	93	90	Glu.	70	48	12
	2	Unknown	270,340,430	56	40	90	46	Glu.	71	48	10
	3	Emodin	222,254,278,290,430	65	-	75	76	Glu.	70	45	10
Leaves	1	Chrysophanol	225,252,275,290, 430	95	18	94	96	Glu.	70	46	10
	2	Rhein	228, 260,430	54	-	80	92	Glu.	71	45	10
Roots	1	Chrysophanol	225, 254,279,290,430	95	18	94	96	Glu.	71	47	10
	2	Unknown	290,320,410	40	-	-	81	Glu.	71	45	9
Stems	1	Chrysophanol	225,254,280,290,432	95	18	94	96	Glu.	71	47	10
	2	Unknown	280,380,390,420	38	0	22	48	Glu.	71	47	10
Seeds	1	Chrysophanol	225,254,275,292,430	96	18	95	95	Glu.	71	47	10
	2	Chrysophanol	225,254,292,430	95	16	96	94	Glu.	70	46	10
	3	Unknown	260,290,320,410	56	30	-	60	Glu.	71	45	9

Occidentalis linn

S.C - Sugar component

Glu.- Glucose

TABLE 6(B): The aglycone components of glycosides from various parts of *C.suratensis.*

Plant Part	Compound No.	Aglycone components	UV Maxima (in nm) (in methanol)	Rf(x100)System				S.C	Rf(x100) System		
				1	2	3	4		1s	2s	3s
Flowers	1	Chrysophanol	225,254, 280,290,430	96	18	93	95	Glu.	70	47	8
	2	Emodin	223,254,262,438	65	-	74	75	Glu.	71	45	10
Leaves	1	Physcion	224,250,260,270,430	93	16	91	90	Glu.	71	47	10
	2	Emodin	222,252,260,438	65	-	74	76	Glu.	70	46	9
Roots	1	Unknown	210,260,320,418	80	-	-	42	Glu.	71	45	10
Pods (without seeds)	1	Chrysophanol	225,254,290,430	95	17	92	94	Glu.	72	46	12
Stems	1	Chrysophanol	224,254,278,290,430	95	16	93	94	Glu.	71	48	10
	2	Unknown	210,285,320	46	44	-	62	Glu.	73	46	12
Seeds	1	Chrysophanol	224,254,280,280,430	96	18	93	95	Glu.	71	45	10
	2	Emodin	222,252,260,430	67	-	74	77	Glu.	71	47	10
	3	Unknown	256,290,300	74	15	41	50	Glu.	71	46	9
	4	Unknown	320,375,400	46	40	32	48	Glu.	70	45	10

S.C - Sugar component

Glu. - Glucose

TABLE 6 (C): The aglycone components of glycosides from various parts of *cassia tora* linn

Plt	Compound No.	Aglycone components	UV Maxima (in nm) (in methanol)	Rf (x100) System				S.C	Rf (x100)System		
				1	2	3	4		1s	2s	3s
ers	1	Aloe-emodin	224, 260, 282,284	50	-	64	66	Glu.	71	47	10
	2	Unknown	242,390, 440	40	20	18	-	Glu	70	45	8
Lves	1	Physcion	225,254,265,269,430	94	15	93	92	Glu.	72	46	10
	2	Emodin	223, 254, 262, 292, 430	65	-	74	75	Glu.	71	47	10
	3	Unknown	290, 440,450	46	-	-	48	Glu.	70	46	10
ts	1	Unknown	210,340,390	40	20	-	18	Glu.	71	47	9
s	1	Unknown	290,320,410	38	-	42	56	Glu.	72	48	12
Seds	1	Chrysophanol	225,254,279,290,430	96	18	94	95	Glu.	71	47	10
	2	Emodin	223, 254, 260, 290, 430	65	-	74	76	Glu.	70	45	9
	3	Aloe- emodin	224, 262, 280, 285	68	-	65	69	Glu.	71	46	10
	4	Unknown	262, 285, 392	46	-	38	58	Glu.	71	45	10

S.C – Sugar component

Glu. - Glucose

Identification of sugars

Fehling's solution test, benedict's solution test and molish test were applied for the presence of sugars. After acid hydrolysis of glycosides, the aqueous layers obtained were neutralized with sodium hydroxide and applied on silica Gel G plate impregnated with 0.02 M sodium acetate, along with the reference samples of glucose, fructose rhamnose, arabinose and sucrose. The chromatograms were developed in the following solvent systems.

1s Acetone- water (90 +10)

2s Acetone –water-chloroform-methanol (75+5+10+10)

3s Ethyl acetate-65% isopropanol (65+35)

The developed chromatograms were removed, air dried and sprayed with aniline.

The developed chromatograms were removed, air dried and sprayed with aniline diphenylamine phosphoric acid reagent and heated for 10 minutes at 85°C. Authentic samples showed coloured spots while the greyish black spot of the test samples were also formed and corresponded with the authentic samples of glucose. The sugar identified was found to be glucose in all the cases. The colour of the rf values of the aqueous extracts obtained after acid hydrolysis are presented in table 6 (A),(B),(C) for *C. occidentalis, C. surattensis, C. tora* respectively.

Estimation of O-glycosides

Free anthraquinone were completely removed with chloroform and aqueous extracts were acid hydrolysed and the hydrolysed materials were extracted with chloroform.50 microlitres of these chloroform extracts were applied as spots to silica gel G plates.

These were then developed in the solvent system no. 1 i.e. benzene:ethy formate:formic acid (74:24:1). The plates were developed and the spots were scraped and eluted in 10 ml of portions of methanol (UV Spectroscopic grade). Now the absorbance of these solutions were determined by using the Baush and Lomb's spectronic "21", spectrophotometer at their respective wavelength i.e. rhein 230 nm, physcion 254nm, emodin 255 nm, chyrsophanol 258 nm, aloe- emodin 260 nm and unknown at 230 nm (in terms of rhein).

Table 7 (A), (B), (C) show the percentages of O-glycosidic aglycones in the various parts of *C. occidentalis, C. surattensis, C. tora*. The results were obtained by using known extinction coefficients as reported by Fairbairn(1972).

TABLE: 7(A) The percentage of o_ glycosidic aglycone in various parts of *cassia occidentalis* linn

Plant part	percentage in dry weight						
	Rhein	Physcion	Emodin	Chrysophanol	Aloe – emodin	Unknown calculated in term of rhein	Total
Flowers	-	0.0896	0.074	-	-	-	0.1680
Leaves	0.1956	-	0.0894	0.0328	-	-	0.3178
Roots		-	-	0.0688	-		0.0688
Pods (without seeds)	-	-	-	-	0.0956	-	0.0956
Stems	-	-	-	0.0910	-	0.0395	0.1305
Seeds	0.0768	0.0622	-	0.0998	-	-	0.2388
Total	0.2724	0.1518	0.1678	0.2924	0.0956	0.0395	1.0195

TABLE 7(B): The percentage of O-glycosidic aglycones in various parts of *cassia surattensis*

Plant Part	P ercentage in dry weight						
	Rhein	Physcion	Emodin	Chrysophanol	Aloe – emodin	Unknown calculated terms of rhein	Total
Flowers	-	-	-	0.0866	-	0.0994	0.1860
Leaves	0.1158	-	0.1175	-	-	0.0396	0.2729
Roots	-	-	0.11750.11750.11750.1175	0.0696	-	0.0446	0.1142
Pods (without seeds)	-	-	-	0.0308	-	-	0.0308
Stems	-	-	-	0.0308	-	-	0.0308
Seeds	-	0.1195	-	0.0728	-	-	0.0728
Total	0.1158	0.1195	-	0.1120	0.0686	-	0.3001

TABLE 7(C): The percentage of O-glycosidic aglycone in various parts of *cassia tora* linn

Plant Part	Percentage in dry weight						
	Rhein	Physcion	Emodin	Chrysophanol	Aloe – emodin	Unknown calculated in terms of rhein	Total
Flowers	-	-	-	-	0.0810	0.1750	0.2560
Leaves	0.1168	-	0.1898	-	-	0.1100	0.4166
Roots	-	-	-	0.1156	-	-	0.1156
Pods (without seeds)	-	-	-	-	-	0.0615	0.0615
Stems	-	-	-	0.0645	-	-	0.0645
Seeds	0.0986	0.0686	0.1184	-	-	-	0.2856
Total	0.2154	0.0686	0.3082	0.1801	0.0810	0.3465	1.1998

Separation of Sennosides

Kapadia and Khorana (1961) established a paper chromatographic method for separation of sennosides using the mixtures of butanol: 1.93 N glacial acetic acid: water (40:10:50). These gave the best separation of sennosides when the test samples (aqueous extract of leaves) were applied along with the authentic samples of sennosides A and B. the test samples gave the spots of same colour and the Rf values as that of sennosides A and B.

Cassia occidentalis showed the presence of the sennosides A. *Cassia surattensis* showed a spot of sennoside A and a faint spot of sennoside B. *Cassia tora* gave a prominent spot of sennoside A and a faint spot of sennoside B.

The quantity of sennosides in leaves of *Cassia occodentalis Cassia surattensis* and *Cassia tora* were estimated by accurately weighing 0.5 gm of leaves and boiled in 90ml of water and vigorously shaken for 10 minutes. The pH of the extracts were adjusted to 6-7 by adding the sodium hydroxide solutions, cooled and filtered. The infusions were diluted with water. 10 ml of the filtrates were quantitatively transferred into a separating funnel and pH was adjusted to 3 by adding 1 N HCl acid. These were then exracted with 60 ml and 40 ml portions of ether respectively till the extracts became colourless. Ether fractions were washed thrice with 5 ml portions of acidified water and combined. These solutions were then transferred into 100 ml volumetric flask and filled upto the mark 0.05 M borax solutions. In 25 ml of volumetric flask containing 60 mg of sodium dithionate were added 10 ml of extracted solutions. Now 10 ml of 0.05 M borax solutions were added, the flask were stoppered and immersed in a boiling water bath for 30 minutes. Cooled and filled the flasks upto the mark with 0.05 M

borax solutions. The experiments wre repeated by adding 10 ml of solutions to 25 ml of volumetric flasks without the addition of dithionite.

The absorbance were measured in stopped cells at 390 nm against blank using Baush and Lomb's spectronic '21' spectrophotometer. The absorbance differences were calculated and concentrations were computed from the standard curve using pure samples of sennosides A(fig. 2) the percentage of sennoside A was found to be 0.05982% in leaves of *Cassia occidentalis*, sennosides A, 0.06435% and sennoside B 0.0268% in *C.surattensis*, while Sennoside A, 0.06282% and sennoside B, 0.2448% *Cassia tora*.

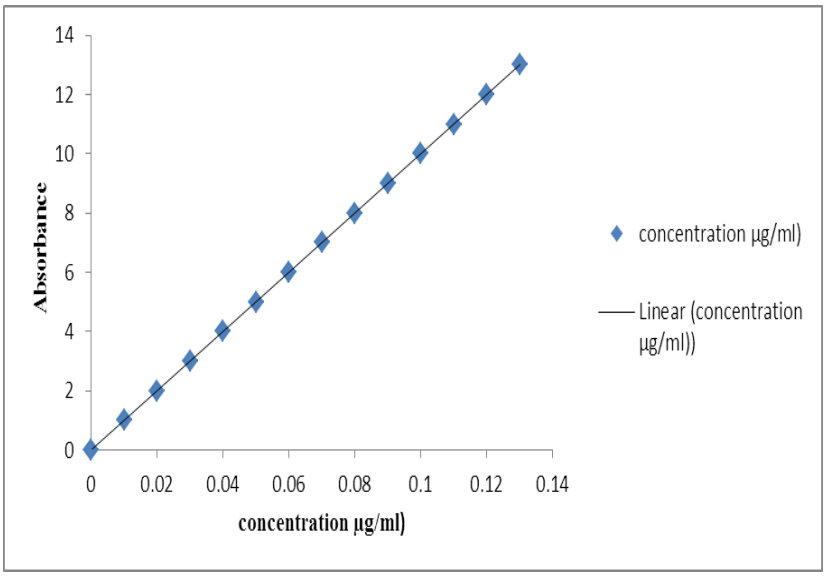

Figure 2: Standard curve of sennoside (a)

C-glycosides

After complete removal of free aglycone and o-glycosidic aglycones, the aqueous extracts were treated with 10%w/v ferric chloride solutions and concentrated hydrochloric acid. These were then refluxed for 20 minutes in a boiling water bath, and then extracted with chloroform. The chloroform extracts were concentrated and applied on the silica geL G plates and chromatograms were developed in the solvent systems nos. 1,2,3 and 4.

C.occidentalis extracts showed rhein, emodin, chrysophanol and aloe-emodin but *C.surattensis* showed the presence of rhein, emodin and aloe emodin, *C.tora* found to contain rhein and aloe emodin.

Identification of sugars

The same method was adopted as in case of o-glycosides test samples gave only one spot of greyish black colour having the same Rf value as the colour was also the same as of these standard samples of glucose in all cases.

Estimation of C-glycosides

50 microlitres of chloroform extracts obtained after oxidative hydrolysis wre applied on silica gel G plates and the chromatograms were developed in solvent system no. 1 i.e. benzene:ethyl formate: formic caid (74:24:1). The developed spots were scraped and eluted in10 ml methanol. Methanol extracts were centrifuged for 10 minutes at 2000rpm. The clear solutions were taken and absorbance were measured. Quantitative estimation were done by using known extinctions coefficients as reported by Fairbairn(1972). The percentage of C-glycoside from various parts of *C.occidentalis*, *C.surattensis* and *C.tora* are shown in Table 8(A),(B),(C) respectively.

TABLE 8 (A): The percentage of c- glycosidic aglycones in various parts of *cassia occidentalis* linn

Plant part	Percentage in Dry Weight			
	Rhein	Emodin	Chrysophanol	Total
Flowers	-	0.0700	-	0.0700
Leaves	0.1164	0.1188	0.0840	0.3192
Roots	-	-	0.0496	0.0496
Seeds	0.0865	-	-	0.0865
Total	0.2029	0.1888	0.1336	0.5253

TABLE 8 (B): The percentage of c-glycosidic aglycones in various parts of *cassia surattensis*

Plant part	Percent in Dry Weight			
	Rhein	Emodin	Chrysophanol	Total
Flowers	-	-	0.0850	0.0850
Leaves	0.0765	0.0708	-	0.1473
Stems	-	-	0.0512	0.0512
Seeds	-	0.0564	-	0.0564
Total	0.0765	0.1272	0.1362	0.3399

TABLE 8(C): The percentage of c-glycosidic aglycones in various parts of *cassia tora* linn

Plant Part	Percentage in Dry Weight			
	Rhein	Emodin	Chrysophanol	Total
Flowers	-	-	-	-

Leaves	0.1492	0.0506	-	0.1998
Stems	-	-	0.0408	0.0408
Seeds	0.0540	-	-	0.0540
Total	0.2032	0.0506	0.0408	0.2946

RESULTS AND DISCUSSION

In the present investigation the pattern of anthraquinone derivatives of *Cassia occidentalisCassia surattensis* and *Cassia tora* have been studied. The three species contain free as well as combined anthraquinone derivatives in leaves, flowers, seeds, stems, pods (without seeds) and roots. The anthraquinone derivative freely were found to be physcion and emodin in flower, rhein, physcion, chrysophanol and aloe emodin in seeds of *Cassia occidentalis*. Physcion, emodin, chyrsophanol, and an unknown in flowers, rhein, emodin, chrysophanol and an unknown in roots, chrysophanol in pods(without seeds) and stem of cassia surratensis.

The various parts of *Cassia tora* such as flowers were found to contain aloe emodin and an unknown leaves were found to contain rhein, emodin and an unknown chrysophanol was found to be present in stem. Seeds were found to be contain rhein, physcion, emodin, chrysophanol and aloe-emodin. The percentage of each of the constituents of free anthraquinone derivatives was determined by the method of Fairbairn (1972). Out of these three species *Cassia occidentalis* was found to contain maximum amount, 1.1074% of total free anthraquinons derivatives, The maximum of rhein in all parts of *Cassia tora* was found to be 0.174% while it was only 0.0565% in *Cassia surrattensis*. Physcion and emodin were found to be 0.2846% and 0.2304% as the maximum amount in *Cassia occidentalis* respectively. The maximum amount of chrysophanol (0.2622%) was found to be present in *Cassia surrattensis*.

Maximum amout of rhein was found to be present in seeds of *Cassia occidentalis*. The percentage of physcion was found to be almost equal in the seeds of *Cassia occidentalis*, *Cassia surattensis* and *Cassia tora*. The percentage of emodin was found to be maximum in flowers of *cassia surrattensis*. The percentage of chyrsophanol was maximum in the roots of *cassia surattensis* and the percentage of aloe emodin was maximum in leaves of *Cassia occidentalis*. Aloe emodin was found to be maximum in all parts of *C.occidentalis.*

The comparative study of the occurrence and concentration of free anthraquinone derivatives give an idea of the site of formation of the anthraquinone derivatives in the species

investigated in the present study. O-glycosides aglycones present in *Cassia occidentalis, Cassia surattensis* and *cassia tora* are rhein physcion,emodin chrysophanol and aloe emodin together with some unknown rhein and physcion (O-glycosidic aglycones) were found to be maximum i.e. 0.2724% and 0.1518% in cassia occidentalis respectively. *Cassia tora* was found to contain maximum amount of emodin 0.3082% as O-glycosidic aglycone. Chyrsophanol (O-glycosidic aglycone) was found to be highest, 0.371% in *Cassia surattensis*. *Cassia occidentalis* was found to contain aloe-emodin (o-glycosidic aglycone) in maximum amount 0.0956%. But the total amount of O-glycosidic aglycones were found to be 1.0195% .0.9768%, 1.998% in *Cassia occidentalis, Cassia surratensis* and *cassia tora* respectively. Rhein, emodin and chrysophanol were found to be the aglycones of C-glycosides in various parts of these species. The maximum amount of rhein and emodin (C-glycosidic aglycones) were present in *Cassia occidentalis* while chrysophanol (O-glycosides) were found to be present in maximum amount in *Cassia surattensis*. The total percentages of c-glycosides were 0.5253%, 0.3399%, and 0.2946% in various parts of *Cassia occidentalis, Cassia surratensis and Cassia tora* respectively. The maximum amount of chrysophanol (0.2622%) were found to be present in *Cassia surattensis*.

The maximum amount of rhein was found to be present in seeds of *Cassia occidentalis*. The percentage of physcion was found to be almost equal in seeds of *Cassia occidentalis, Cassia surattensis, Cassia tora*. The percentage of emodin was found to be maximum in flowers of *Cassia surattensis*. The percentage of chyrsophanol was maximum in the roots of *Cassia surattensis* and the percentage of aloe-emodin was maximum in the roots of *Cassia surattensis* and the percentage of aloe-emodin was maximum in leaves of *Cassia occidentalis*. Aloe –emodin was found to be maximum in all parts of *C.occidentalis*. O-glycosidic aglycones present in *Cassia occidentalis, Cassia surattensis* and *cassia tora* are rhein, physcion,emodin, chyrsophanol and aloe-emodin together with some unknowns rhein and physcion (O-glycosidic) aglycones were found to be maximum i.e. 0.2724% and 0.1518% in *Cassia occidentalis* respectively. *Cassia tora* was found to contain maximum amount of emodin 0.3082% as o-glycosidic aglycones. chyrsophanol (O-glycosidic aglycones) was found to be highest, 0.3718% in *Cassia surattensis. Cassia occidentalis* was found to contain aloe emodin (O-glycosiodic aglycones) in maximum amount 0.0956% but the total amount of O-glycosidic aglycones were found to be 1.0195%, 0.9768% and 1.1998% in *Cassia occidentalis, Cassia surattensis* and *Cassia tora* respectively. Rhein ,emodin and chrysophanol were found to be the aglycones of C-glycosiides in various parts

of these species. The maximum amount of rhein and emodin (C-glycosidic aglycones) were present in *Cassia occidentalis*. While chrysophanol (O-glycosidic aglycones) was found to be present in maximum amount in *Cassia surattensis*. The total percentage of C-glycosides aglycones were 0.5253%, 0.3399% and 0.2946% in various parts of *Cassia surattensis, Cassia tora* respectively.

Taking into consideration and comparative representation of total percentage of anthracene derivatives (free and combined form)in *Cassia occidentalis, Cassia surrratensis, Cassia tora*, it was observed (figure 3) that physcion rhein and aloe–emodinwere found to be major constituents ,chrysophanol was found to be major constituents in *Cassia surrattensis*. But emodins and unknowns were the major constituents of *Cassia tora*.

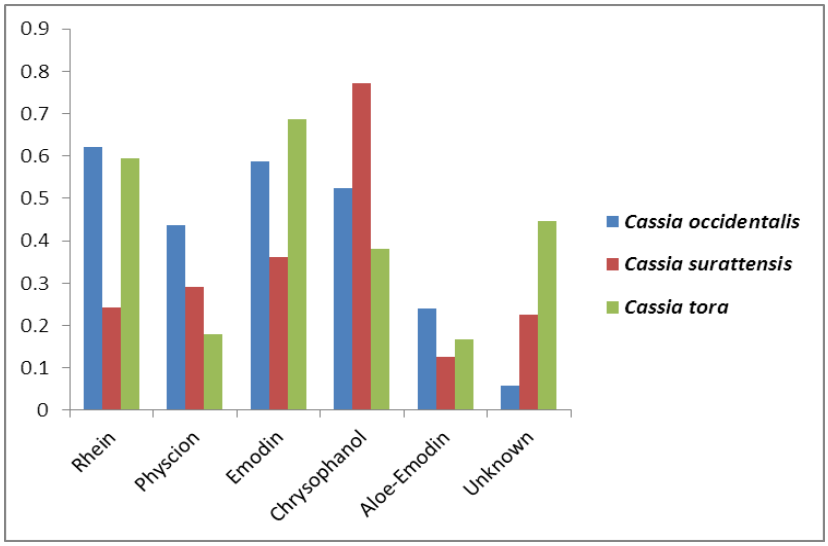

Figure 3: Comparative representation of total percentage of anthracene derivatives (free and combined forms) in *Cassia occidentalis, Cassia surattensis* and *Cassia tora.*

By the method of Lemli (1965) and Fairbarin (1972) total percentages of anthracene derivatives were found and the results are represented in the table 9(A),(B),(C) The results are almost identical in both the methods the genus cassia in family leguminoseae(sub family-caselpinaceae).

TABLE 9 (A): The percentage of total glycoside aglycones in various parts of *cassia occidentalis* linn

Plant Part	Total Percentage in Dry Weight			
	C-Glycosidic Aglycones	O-Glycosidic Aglycones	Method of Fairbairn (1972)	Method of Lemli (1965)
Flowers	0.0700	0.1680	0.2380	0.2400

Leaves	0.3192	0.3178	0.6370	0.6400
Roots	0.0496	0.0688	0.1184	0.1260
Pods (without seeds)	-	0.0956	0.0956	0.1000
Stems	-	0.1305	0.1305	0.1400
Seeds	0.0865	0.2388	0.3253	0.3400

TABLE 9 (B): The percentage of total glycosidic aglycones in various parts of *cassia surattensis*

Plant Parts	Total percentage in Dry Weight			
	C- Glycosidic Aglycones	O-Glycosidic Aglycones	Method of Fairbairn (1972)	Method of lemli (1965)
Flowers	0.0850	0.1860	0.2710	0.3000
Leaves	0.1473	0.2729	0.4202	0.4300
Roots	-	0.1142	0.1142	0.1200
Pods (without seeds)	-	0.0308	0.0308	0.0560
Stems	0.0512	0.0728	0.1240	0.1300
Seeds	0.0564	0.3001	0.3565	0.3600

TABLE 9(C): The percentage of total glycosidic aglycones in various parts of *cassia tora* linn

PlantsParts		Total Percentage in Dry Weight		
	C-Glycosidic Aglycones	O-Glycosidic Aglycones	Method of Fairbairn (1972)	Method of Lemli (1965)
Flowers	-	0.2560	0.2560	0.2600
Leaves	0.1998	0.4166	0.6164	0.6400
Roots	-	0.1156	0.1156	0.1600
Pods (without seeds)	-	0.0615	0.0615	0.0640
Stems	0.0408	0.0645	0.1053	0.1100
Seeds	0.0540	0.2856	0.33396	0.3400

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