release in the 24 hour samples. In addition, no quercetin release was detected from the liposomes at 24 hours, suggesting that the phytosomes (but not the liposomes) has the ability to serve as carriers for both flavonoid glycosides and aglycones.

To determine whether one or all of the sutherlandins would be required if one wishes to compare the API release character or quality of *Sutherlandia* containing liposomes or phytosomes at pH 1.2, the release profiles and data presented in figure 5.2 and table 5.1 were considered.

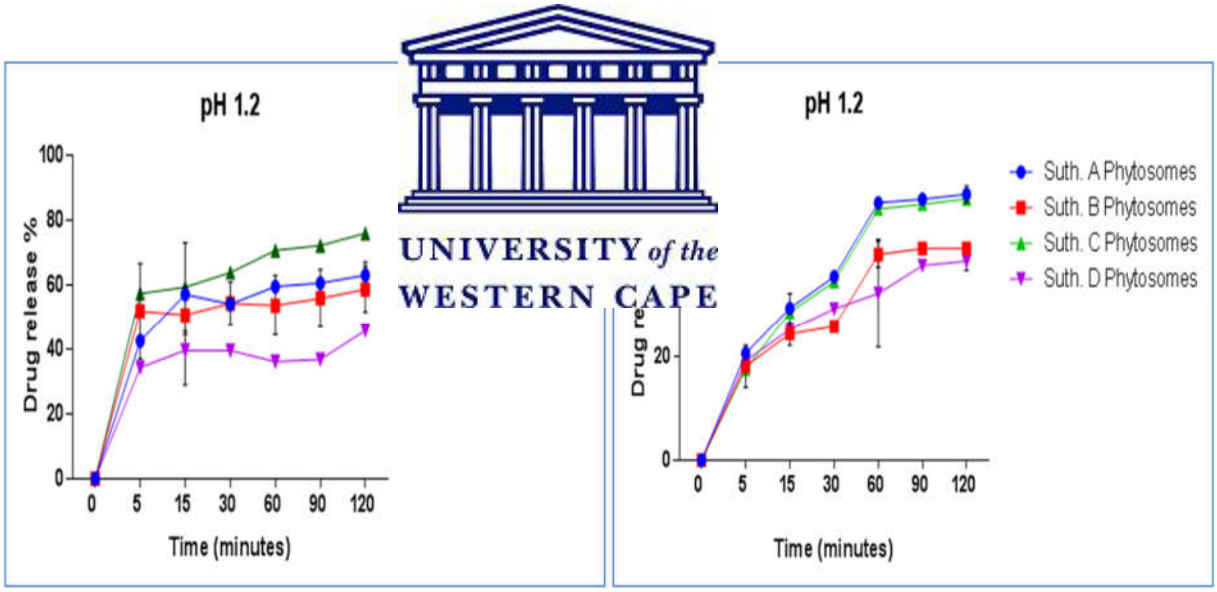


Figure 5.2 Release profiles of individual sutherlandins A, B, C and D from *S. frutescens* liposomes and phytosomes at pH 1.2.

Table 5.2: Comparison of release profile of individual sutherlandins A, B, C, and D from liposomes at pH 1.2

Sutherlandin comparison	Similarity factor (f_2)	Inference

Suth A vs Suth B	**61**	**Release profile similar**
Suth A vs Suth C	**46**	**Release profile dissimilar**
Suth A vs Suth D	**39**	**Release profile dissimilar**
Suth B vs Suth C	**41**	**Release profile dissimilar**
Suth B vs Suth D	**43**	**Release profile dissimilar**
Suth C vs Suth D	**27**	**Release profile dissimilar**

For sutherlandin release from the liposomes at pH 1.2, the f_2 values were all below 50 with the exception of sutherlandin A *versus* sutherlandin B ($f_2 = 61$). This implies that the release profiles of sutherlandins A and B were similar but dissimilar for all the other comparisons (i.e. A *versus* C, A *versus* D, B *versus* C, B *versus* D, and C *versus* D). This could be because sutherlandins A and B are glycosides of the same aglycone, quercetin. However, if this is so, then we expected the release profiles of sutherlandins C and D to be similar as well because they are glycosides of the same aglycone, viz. kaempferol. This was not the case though. It may be that glycosides of quercetin are more similar than glycosides of kaempferol, and the difference in the sugar moieties of sutherlandins C and D could also contribute to the dissimilarity of their release profiles. No evidence to substantiate or refute this proposition could however be found in literature.

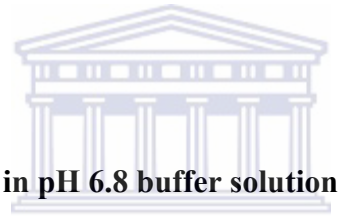
For the phytosomes, the results of the release profile comparisons of the different sutherlandins at pH 1.2 are presented in figure 5.2 and table 5.3.

Table 5.3: Comparison of release profile of individual sutherlandins A, B, C, and D from phytosomes at pH 1.2

Sutherlandin comparison	**Similarity factor (f_2)**	**Inference**
Suth A vs Suth B	**54**	**Release profile similar**
Suth A vs Suth C	**87**	**Release profile similar**
Suth A vs Suth D	**50**	**Release profile similar**
Suth B vs Suth C	**54**	**Release profile similar**
Suth B vs Suth D	**50**	**Release profile similar**
Suth C vs Suth D	**74**	**Release profile similar**

In this case the f_2 values were all above 50, implying similarity of the release profiles of all the sutherlandins from the phytosome preparations. This is different from what was obtained with the liposomes where most of the sutherlandins showed dissimilarity in drug release profiles. It could well be that the phytosome preparation masks the characteristics of individual sutherlandins, so that their release depend on the enclosing material while in the liposome preparation the individual characteristics of the sutherlandins are preserved leading to differences in sutherlandin release from the liposomes but not from the phytosomes. These observed differences could also be due to the bonding characteristics of the sutherlandins being different within the phytosomes but not within the liposomes. No confirmation of these possibilities was however found in the literature.

Collectively, the above results indicated that there were significant differences in the release profiles of the *S. frutescens* flavonoid glycosides from liposomes *versus* phytosomes at pH 1.2 i.e. in gastric conditions, a characteristic shown by all the individual sutherlandins. The differences observed might reflect differences in the sutherlandin encapsulation efficacy or surface area in the liposomes and phytosomes. In addition, for comparison of API release from different phytosome preparations of Sutherlandia, as a product quality control specification, any of the 4 sutherlandins can be considered, but not for liposome preparations, in which case all 4 marker compounds should be used.



5.4.2 Sutherlandin release in pH 6.8 buffer solution

The total amounts (AR_{120}) and rates (T_{AR50}) of sutherlandins (A to D) released from the liposomes and phytosomes are presented in table 5.4, figure 5.3 and Appendix 4 (i.e. the data from which the graphs were plotted).

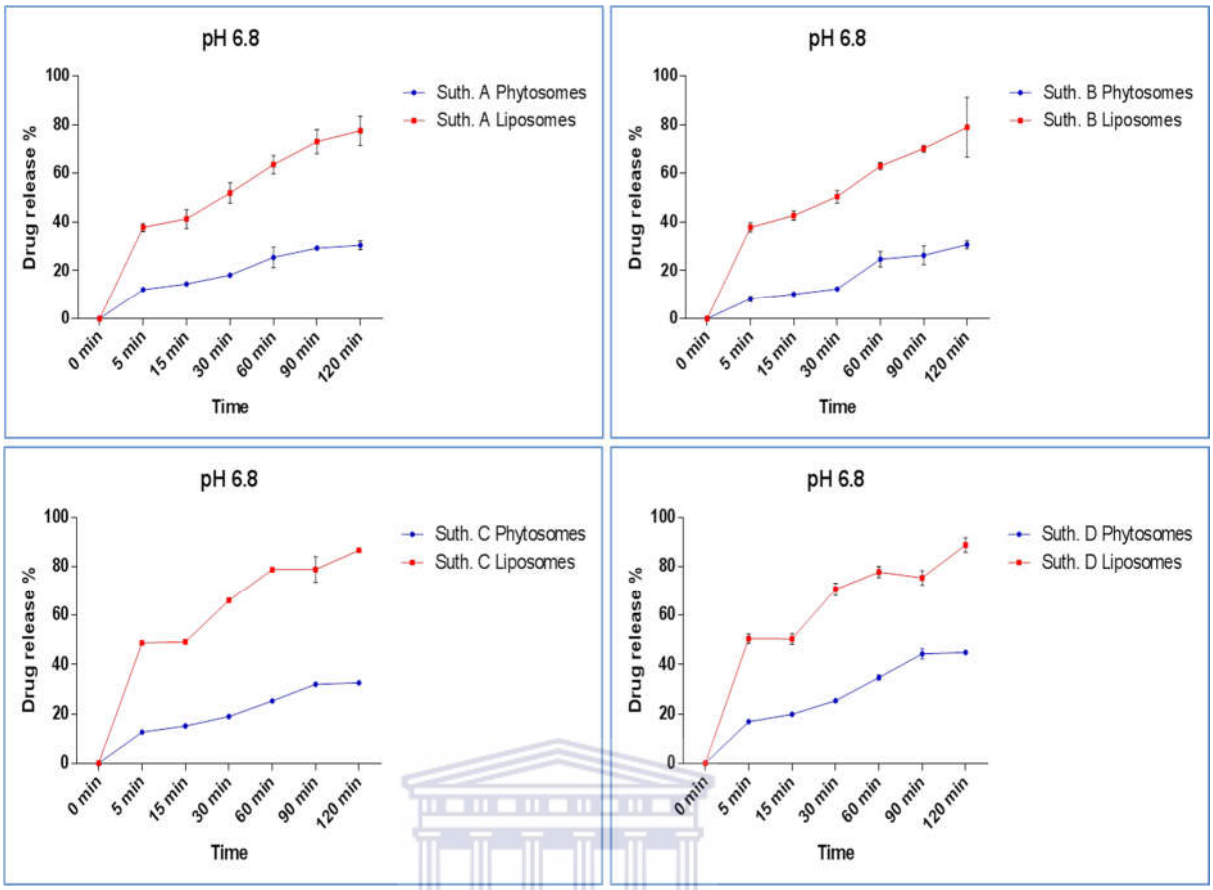


Figure 5.3: Release profiles of sutherlandins A, B, C and D from *S. frutescens* liposomes *versus* phytosomes at pH 6.8.

Neither the liposomes nor the phytosomes released all (i.e. 100 %) of the individual sutherlandins after 120 mins in pH 6.8 buffer (i.e. $AR_{120} < 100$ %) and the amounts released at all time points were significantly (**p = 0.001** for sutherlandins A and **p = 0.0008** for sutherlandin B, C and D), higher for the liposomes than that from the phytosomes. The amounts of sutherlandins A, B, C, and D released from the liposomes at 120 mins, as a percentage of the total amount of the encapsulated *S. frutescens* material, were 77.47, 75.78, 86.76 and 88.86%, respectively, and 30.55, 30.76, 32.65 and 44.93%, respectively for the phytosomes. Despite the higher flavonoid encapsulation efficiency of the phytosomes, established in chapter 4, the

liposomes still released higher amounts of each flavonoid, after 120 minutes in pH 1.2 buffer, than the phytosomes.

The sutherlandins were released at different rates from the liposomes with the time for 50% release (i.e.T_{AR50}) being 5 minutes for sutherlandin D and 30 minutes for sutherlandins A, B and C. These rates were however faster than that for the phytosomes for which the T_{AR50} for all sutherlandins of the phytosomes > 120 minutes.

Table 5.4: The percentage release (AR_{120}) and rate of release T_{AR50} form the liposomes and phytosomes at pH 6.8

Sutherlandins	Liposomes		Phytosomes	
	AR_{120} (%)	T_{AR50} (Minutes)	AR_{120} (%)	T_{AR50} (Minutes)
Sutherlandin A	77.47	30	30.55	> 120
Sutherlandin B	75.78	30	30.76	> 120
Sutherlandin C	86.76	30	32.65	> 120
Sutherlandin D	88.86	5	44.93	> 120

The individual sutherlandin release profiles from the liposomes and phytosomes were also compared and the similarity factors (f_2) for sutherlandins A, B, C and D release from the liposomes *versus* phytosomes were 22, 19, 17 and 21, respectively, clearly indicating the dissimilarities of the release profiles of each sutherlandin from the liposomes *versus* the phytosomes.

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Generally, the liposomes showed faster flavonoid release than the phytosomes. Release of the sutherlandins was also faster at pH 6.8 than at pH 1.2, probably due

to the enhanced solubility of liposomes at higher pH values. The phytosomes, on the other hand, exhibited slower sutherlandin (API) release at pH 6.8. Release of API from solid dosage forms is a complex operation influenced by a number of factors such as differences in surface area, stability, particle size and size distribution (Chiou, *et al* 1971). The significant enhancement of API release from the liposomes compared to the phytosomes could be due to the greater physical stability of the liposomal preparation (confirmed by zeta potential values for liposomes of - 8.55) than that of phytosomes (zeta potential value of - 0.457) (Lim, Kim 2002).The smaller size of the liposome vesicles could be another factor contributing to the increased API release of *S. frutescens* flavonoids. Indeed, it has been demonstrated in a previous study that the minute size of the liposomes provided a bigger surface area compared to that of phytosomes (Ait-Oudhia, *et al.* 2014), and that this hastened API release from the liposomes.

To determine whether one or all of the sutherlandins would be required if one wishes to compare the API release character or product quality of *Sutherlandia* containing liposomes or phytosomes at pH 6.8, the release profiles and data presented in figure 5.4 and table 5.3 were considered.

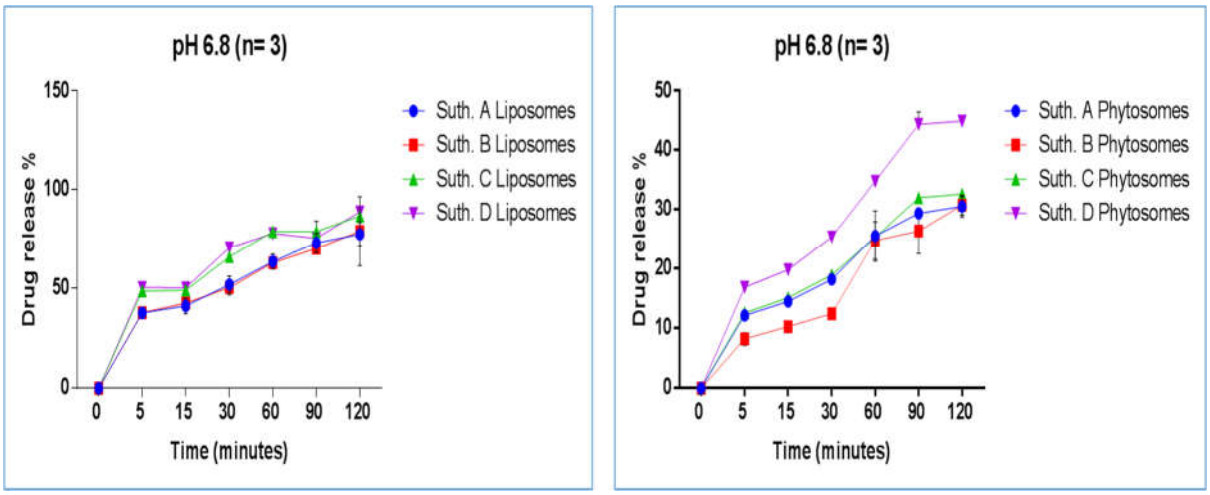

Figure 5.4 **Release profiles of individual sutherlandins A, B, C and D from *S. frutescens* liposomes and phytosomes at pH 1.2.**

Table 5.5: Comparison of release profile of individual sutherlandins A, B, C, and D from liposomes at pH 6.8

Sutherlandin comparison	Similarity factor (f_2)	Inference
Suth A vs Suth B	**75**	**Release profile similar**
Suth A vs Suth C	**48**	**Release profile dissimilar**
Suth A vs Suth D	**45**	**Release profile dissimilar**
Suth B vs Suth C	**51**	**Release profile similar**
Suth B vs Suth D	**48**	**Release profile dissimilar**
Suth C vs Suth D	**56**	**Release profile similar**

Generally the f_2 – values for sutherlandin release from the liposomes at pH 6.8 were higher than those obtained at pH 1.2. At the higher pH the release profiles of sutherlandins A *versus* B, B *versus* C and C *versus* D were similar, but dissimilar

for all the other comparisons (i.e. A *versus* C, A *versus* D, and B *versus* D). This could have been because sutherlandins A and B are glycosides of the same aglycone, quercetin, while sutherlandins C and D are glycosides of the aglycone kaempferol, or it might be also due to increased stability of the liposomes at the higher pH.

The results for the release profile comparisons of the different sutherlandins from the phytosomes at pH 6.8 are presented in figure 5.4 and table 5.6.

Table 5.6: Comparison of release profile of individual sutherlandins A, B, C, and D from phytosomes at pH 6.8

Sutherlandin comparison	**Similarity factor (f_2)**	**Inference**
Suth A vs Suth B	**72**	**Release profile similar**
Suth A vs Suth C	**88**	**Release profile similar**
Suth A vs Suth D	**50**	**Release profile similar**
Suth B vs Suth C	**88**	**Release profile similar**
Suth B vs Suth D	**50**	**Release profile similar**
Suth C vs Suth D	**52**	**Release profile similar**

The f_2 values were all above 50, implying similarity of the release profiles of all the sutherlandins from the phytosome preparations. It could well be that in the phytosome preparation the structural characteristics of individual sutherlandins were masked, so that their release depended on the enclosing material while in the liposome preparation the individual characteristics of the sutherlandins were

preserved leading to differences in sutherlandin release from the liposomes but not from the phytosomes. The observed differences could also be due to the bonding characteristics of the sutherlandins which might also be different within the phytosomes but not within the liposomes. No confirmation for either of these possibilities was however found in the literature.

Collectively, the above results indicated that there were significant differences in the release profiles of the *S. frutescens* flavonoid glycosides from liposomes *versus* phytosomes at pH 6.8 i.e. in intestinal fluid, a characteristic shown by all the individual sutherlandins. The differences observed might reflect differences the encapsulation efficacy or surface area of the API in the liposomes and phytosomes. In addition, for comparison of API release from different phytosome preparations of *Sutherlandia*, (e.g, for product quality control purposes) any of the 4 sutherlandins can be considered, but not for liposome preparations, in which case similarity was only found for *Sutherlandia* A *versus* B, sutherlandin B *versus* C and sutherlandin C *versus* D, and preferably all 4 should be monitored.

5.4.3 Effect of pH on flavonoid release from liposomes and phytosomes.

Finally, the effect that pH had on flavonoid release was also assessed and the results of comparison of sutherlandins A, B, C and D release from the *Sutherlandia* liposomes and phytosomes at pH 1.2 and 6.8 are presented in figures 5.5 and 5.6.

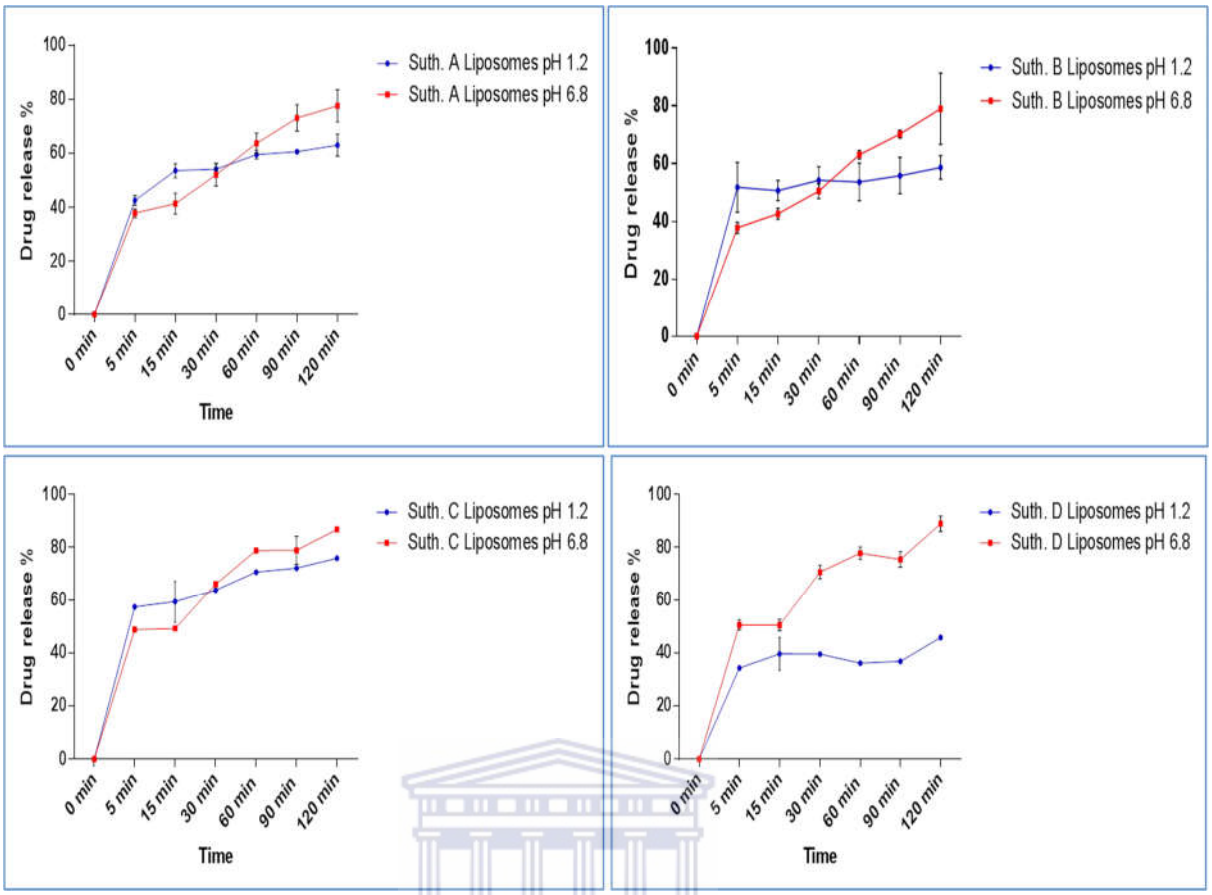

Figure 5.5: Effect of pH on release profiles of sutherlandins A, B, C and D from *S. frutescens* liposomes

The release profile for sutherlandins A and C from *Sutherlandia* liposomes at pH 1.2 *versus* 6.8 were similar with f_2 values of 52, and 54 respectively and pH therefore did not significantly affect the release profile of these sutherlandins. However, the release of sutherlandin B and D from *Sutherlandia* liposomes at pH 1.2 and 6.8 was not similar with f_2 values of 42 and 24, respectively. In addition, for sutherlandin B the release at the 2 pH's was similar up to 60 minutes (with f_2 value 52), but after 60 minutes, it became dissimilar. Finally, the release of sutherlandin D was clearly dissimilar at the 2 pH's and this was most likely due to instability of this API in the media.

For phytosomes, the release profile for sutherlandins A, B and C (with the exception of sutherlandin D, $f_2 = 65$) from *Sutherlandia* phytosomes at pH 1.2 *versus* 6.8 were dissimilar with f_2 values of 22, 44 and 39, respectively. Clearly pH affected the release profile of these 3 flavonoid glycosides from *Sutherlandia* phytosomes Overall, sutherlandin release from the phytosomes **was** more rapid at pH 1.2 than pH 6.8, i.e. release rate was greater increased at the lower simulated gastric pH, while for liposomes change of pH (from 1.2 to 6.8) did not significantly change the sutherlandin release profiles.

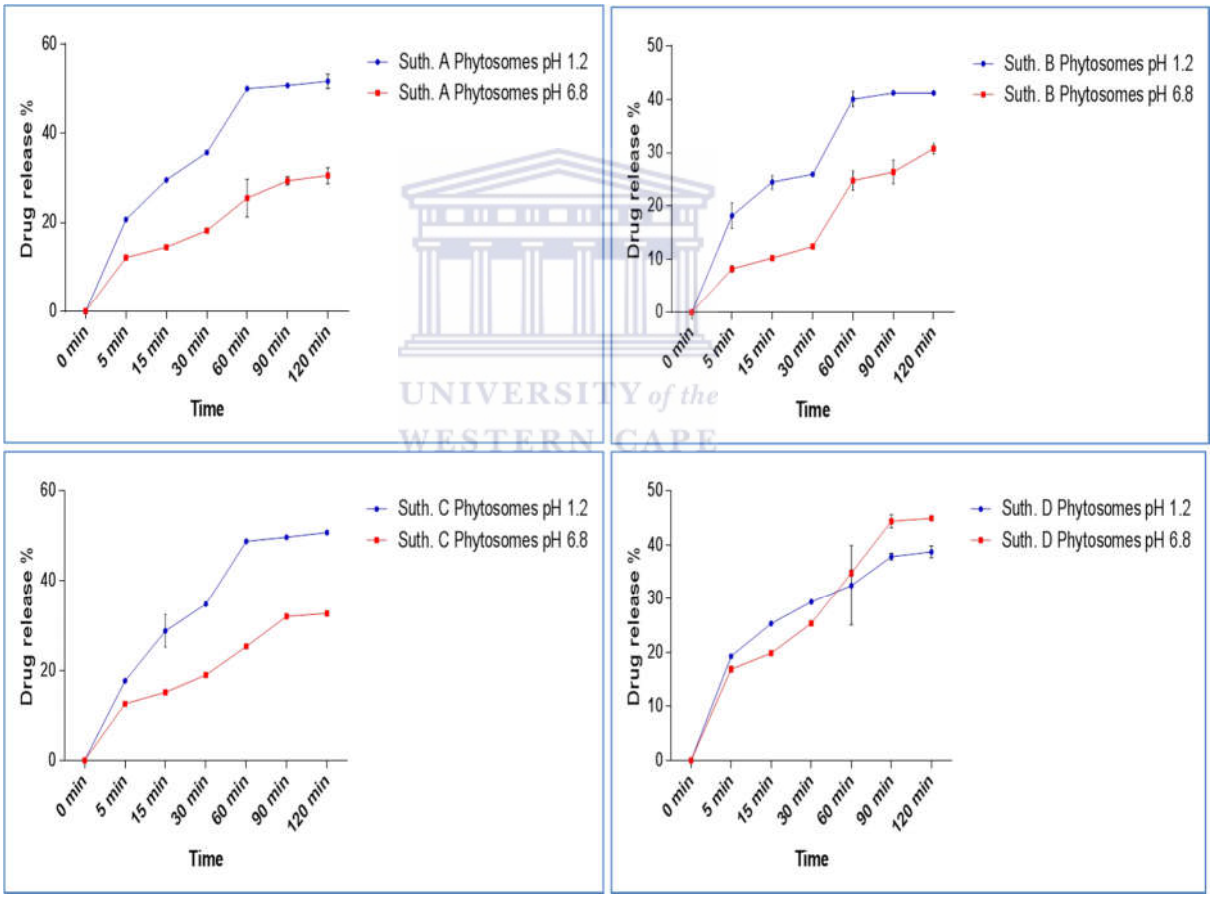

Figure 5.6: Effect of pH on release profiles of sutherlandins A, B, C and D from *S. frutescens* phytosomes

Overall, the release of sutherlandins A, B, C and D, i.e. potential active compounds of *S. frutescens*, was significantly higher and faster, from the liposomes compared to the phytosomes, at both stomach (1.2) intestinal (6.8) pH, confirming the second

hypothesis tested in this study, *viz.* that sutherlandin release would be faster from the liposomes than from the phytosomes. In addition, for product quality control purposes, any of the 4 sutherlandins can be considered for comparison of API release from different phytosome preparations of *Sutherlandia* at both pH 1.2 and 6.8, but not for liposome preparations.

5.5 Conclusion

The objective of this section of the study was to compare the *in vitro* release profiles of flavonoids from *S. frutescens* liposomes *versus* phytosomes. The release profiles of sutherlandins A, B, C and D showed significant differences with higher and faster release rates from the liposomes compared to the phytosomes at both pH 1.2 and 6.8. This may be due to the smaller particle size and narrower particle size range (as confirmed by the polydispersity index) of the liposomes compared to the phytosomes, attributes that facilitated the release of the API upon penetration of the buffer medium through the preparation matrix. Such penetration then resulted in rapid API diffusion. The phytosomes, with a larger size and broad particle size distribution, however released the API more slowly resulting in more delayed release. Finally, for product quality assessment any of the 4 sutherlandins can be considered for comparison of API release from different phytosome preparations of *Sutherlandia* at both pH 1.2 and 6.8, but not for liposome preparations. In the latter all 4 sutherlandins might have to be used to obtain the best assessment.

CHAPTER SIX
Conclusions and Recommendations

The primary aim of this study was to prepare and compare liposomes and phytosomes of *S. frutescens* freeze dried aqueous extract (FDAE) for solid oral dosage form application. The specific objectives were to prepare and physically characterise liposomes and phytosomes of the *S. frutescens* FDAE and to determine the drug release profiles of flavonoids from these liposomes and phytosomes.

From the results obtained in this study, the following major conclusions could be drawn:

1. Both phytosomes and liposomes of *S. frutescens* FDAE can be efficiently prepared using the thin film hydration method. In addition, sonication was an effective method for size reduction of both types of particles, but, in this study, worked better for the liposomes than for the phytosomes of *S. frutescens* FDAE.

2. The optimized liposomes and phytosomes had an appropriate vesicle size and carried a sufficient amount of drug. However, the prepared liposomes had smaller particle size and size distribution as well as a relatively higher zeta potential value than the phytosomes, suggesting that the liposomes had better physical and chemical stability profiles.
3. Phytosomes can encapsulate significantly higher amounts of *S. frutescens* FDAE than do liposomes confirming the first hypothesis, *viz*. that the entrapment efficacy of the phytosomes will be higher than that of the liposomes, tested in this study, and also further strongly indicate that the phytosomes are promising vehicles for delivery of different active constituents of the herbal extract.

4. Finally, the release of sutherlandins A, B, C and D, potential active compounds of *S. frutescens*, was significantly faster, from the liposomes compared to the phytosomes, at both stomach (1.2) and intestinal (6.8) pH, confirming the second hypothesis tested in this study, *viz.* that sutherlandins release would be faster from the liposomes than from the phytosomes.

Collectively, the results obtained strongly suggest that phytosomes could be a very viable particle form for the delivery of flavonoids, and possibly other actives, (i.e. active phytopharmaceutical material) from an aqueous extract of *S. frutescens.*

Overall, this study provides valuable preliminary information on the preparation and evaluation of liposomes and phytosomes of *S. frutescens* aqueous extract. Particularly the phytosomes may be the administration and delivery form to use for systemic delivery of *S. frutescens* and may most likely also be a useful delivery form for dried aqueous extracts of other South African indigenous medicinal plants. More detailed studies on the physical and pharmaceutical properties (e.g. flavonoid or other active compound dissolution profile; stability, etc.) of such products are however needed to confirm this potential usefulness. In addition, *in vitro* and *in vivo* pharmacokinetic studies of *S. frutescens* phytosomal and liposomal products will also be needed. In the immediate future, we however aim to first investigate the optimization of the stability and lamellarity of the phytosomal preparations and the effect which cholesterol, as a formulation (and drug release) stabilizer, may have.

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Appendix 1: **Certificate of analysis for FDAE *S. frutescens.***

Afriplex
SOURCE TO SHELF

CERTIFICATE OF ANALYSIS

Product Code	00814
Batch No.	62265
Product	Sutherlandia PE
Expiry date	May 2015

Characteristic	Specification	Result
Plant material	*Sutherlandia frutescens* herba sicc	Pass
Appearance	A hygroscopic powder with a mustard brown colour	Pass
Odour & Taste	Characteristic with a bitter taste	Pass
Country of origin	South Africa	Pass
Solubility	≥95% Soluble in water	Pass
Moisture	<7% (m/m)	6% (m/m)
Bulk Density	0.2 – 0.5 g/ml	0.4 g/ml
Identity (FT-IR)	≥95.00% similarity when compared to reference	97.57%
Heavy metals		
Lead	<5.0 mg/kg	Not Detected
Cadmium	<0.5 mg/kg	Not Detected
Mercury	<0.1 mg/kg	Not Detected
Arsenic	<1.00 mg/Kg	Not Detected
Microbiological		
Total viable aerobic count	<2000cfu/g	1305 cfu/g
Yeast & Moulds	<100cfu/g	No growth/g
Escherichia coli	Absent/g	No growth/g
Staph. aureus	Absent/g	No growth/g
Salmonella	Absent/25 g	Absent/25 g

STORAGE REQUIREMENTS
Closed container, cool (10 - 25°C) and dry conditions

PAARL, 20 Jun 2013

Afriplex
Quality Control Department

Afriplex
PO Box 3186, Paarl 7620, South Africa Tel: +27 21 872 4976 Fax: +27 21 872 4930

Appendix 2: Flavonoid calibration curves and regression equations.

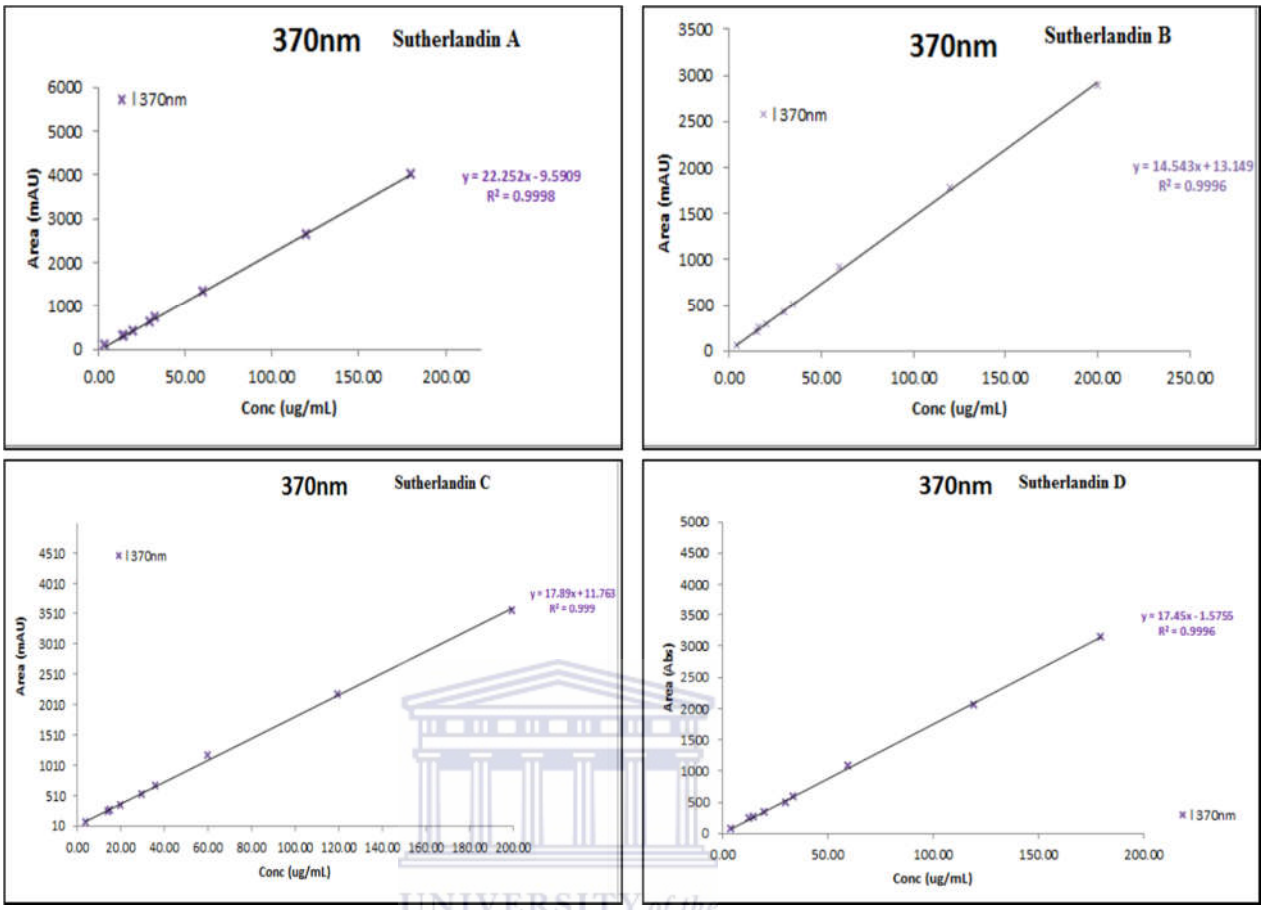

Figure A 2.1: Calibration curves of sutherlandins (A to D) at wavelengths 370 nm.

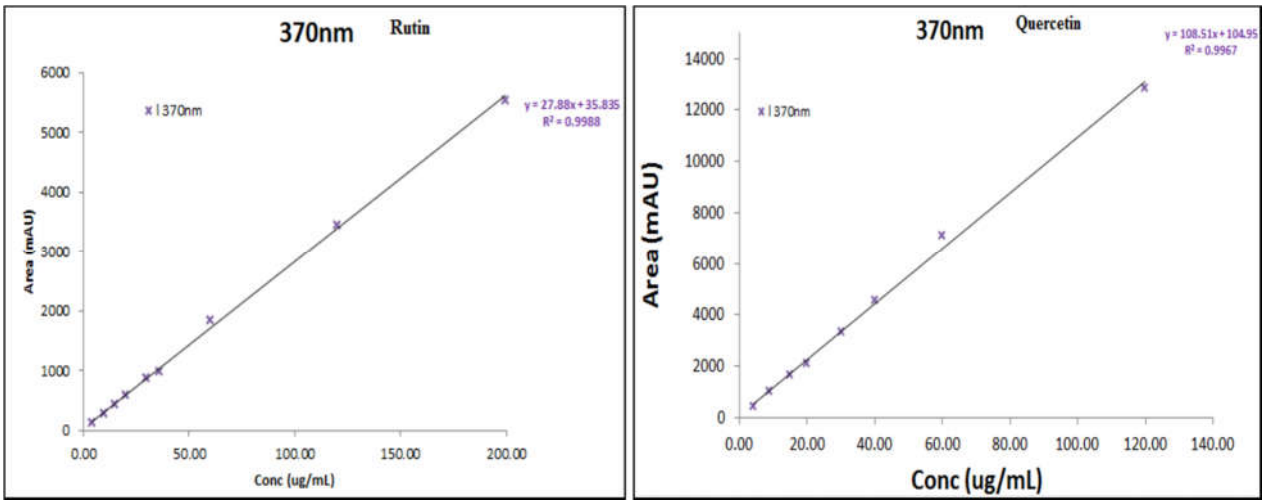

Figure A 2.2: Calibration curves of flavonoid glycoside (rutin) and aglycone (quercetin) at wavelengths 370 nm.

Appendix 3: HPLC peak areas of individual sutherlandins (A to D) released from liposomes and phytosomes and used to calculate entrapment efficacies. The peaks were obtained using method described in section 4.3.8 and detected at 370 nm

Table A3.1: Peak area of individual sutherlandins released from liposomes

Sutherlandin A		Sutherlandin B	
Peak area of starting solution (mAUFs)	Peak area of supernatant (mAUFs)	Peak area of starting solution (mAUFs)	Peak area of supernatant (mAUFs)
723.2	441	1116	814.2
721.8	540	1112.8	816.1
851.2	584	1246	861.5
Sutherlandin C		Sutherlandin D	
Peak area of starting solution (mAUFs)	Peak area of supernatant (mAUFs)	Peak area of starting solution (mAUFs)	Peak area of supernatant (mAUFs)
1569.5	918.7	1168.7	995
1568.6	1188.6	1108.5	775.8
1715	1097.2	1105.9	640.5

Table A3.2: Peak area of individual sutherlandins released from phytosomes

Sutherlandin A		Sutherlandin B	
Peak area of starting solution (mAUFs)	Peak area of supernatant (mAUFs)	Peak area of starting solution (mAUFs)	Peak area of supernatant (mAUFs)
851.2	478.8	1246	697.3
851.2	423	1246	619.6
851.2	422	1246	615
Sutherlandin C		Sutherlandin D	
Peak area of starting solution (mAUFs)	Peak area of supernatant (mAUFs)	Peak area of starting solution (mAUFs)	Peak area of supernatant (mAUFs)
1715.9	1043.1	1168.7	691.5
1715.9	941.4	1168.7	590.8
1715.9	941	1168.7	588.9

Appendix 4: Sutherlandin release *versus* time profiles for FDAE *Sutherlandia* phytosomes and liposomes

Table 4.1: Release versus time profile for sutherlandin A from phytosomes of FDAE Sutherlandia at pH 1.2 and 6.8

	Percentage sutherlandin A released at pH 1.2 (%)		Percentage sutherlandin A released at pH 6.8	
Time (minutes)	AVE ± SD	%CV	AVE ± SD	%CV
0	0 ± 0	0	0 ± 0	0
5	46.560 ± 0.551	1.183	27.400 ± 1.058	3.862
15	66.430 ± 0.321	0.484	32.667 ± 0.115	0.353
30	80.300 ± 0.500	0.623	40.967 ± 0.862	2.105
60	112.460 ± 0.153	0.136	57.400 ± 9.440	16.446
90	114.000 ± 0.436	0.382	66.033 ± 2.155	3.263
120	116.100 ± 3.378	2.909	68.667 ± 4.007	5.835

Table 4.2: Release versus time profile for sutherlandin B from phytosomes of FDAE Sutherlandia at pH 1.2 and 6.8.

	Percentage sutherlandin B released at pH 1.2		Percentages sutherlandin B released at pH 6.8	
Time (minutes)	AVE ± SD	%CV	AVE ±SD	%CV
0	0 ± 0	0	0 ± 0	0
5	73.600 ± 16.639	22.607	33.3 ± 4.099	12.298
15	98.967 ± 8.271	8.358	41.7 ±0.608	1.459
30	104.900 ± 1.868	1.781	50.4 ± 0.520	1.031
60	161.633 ± 9.059	5.605	100.1 ± 12.002	11.990
90	166.450 ± 3.465	2.082	106.6 ± 14.880	13.959
120	166.950 ± 2.758	1.652	124.233 ± 6.799	5.473

Table 3: Drug release versus time profile for sutherlandin C from phytosomes of FDAE Sutherlandia at PH 1.2 and 6.8

	Percentage sutherlandin C released at pH 1.2		Percentage Sutherlandin C released at pH 6.8	
Time (minutes)	**AVE ± SD**	**%CV**	**AVE ± SD**	**%CV**
0	0 ± 0	0	0 ± 0	0
5	84.633 ± 0.702	0.830	60.233 ± 0.603	1.001
15	137.633 ± 17.960	13.049	72.400 ± 0.954	1.318
30	166.400 ± 0.400	0.240	90.867 ± 1.266	1.394
60	233.533 ± 0.208	0.089	121.067 ± 0.404	0.334
90	237.867 ± 0.850	0.358	153.133 ± 0.850	0.555
120	242.767 ± 0.611	0.252	156.233 ± 1.922	1.230

Table 4: Drug release data for sutherlandin D from phytosomes of FDAE Sutherlandia at PH 1.2 and 6.8

	Percentage sutherlandin D released at pH 1.2		Percentage sutherlandin D released at pH 6.8	
Time (minutes)	**AVE ± SD**	**%CV**	**AVE ± SD**	**%CV**
0	0 ± 0	0	0 ± 0	0
5	53.900 ± 1.217	2.257	47.300 ± 2.042	4.317
15	71.000 ± 1.900	2.676	55.567 ± 1.422	2.560
30	82.367 ± 2.316	2.812	71.067 ± 0.839	1.180
60	97.867 ± 24.999	25.544	97.400 ± 1.153	1.184
90	105.300 ± 3.666	3.482	124.267 ± 4.500	3.622
120	108.467 ± 4.932	4.547	125.800 ± 1.308	1.039

Table 5: Drug release data for sutherlandin A from liposomes of FDAE Sutherlandia at PH 1.2 and 6.8

	Percentage Sutherlandin A released at pH 1.2		Percentage sutherlandin A released at pH 6.8	
Time (minutes)	**AVE ± SD**	**%CV**	**AVE ± SD**	**%CV**
0	0 ± 0	0	0 ± 0	0
5	72.9 ± 2.1	1.6	64.800 ± 1.637	2.526
15	83.06 ± 27.1	32.7	70.933 ± 7.569	10.671
30	92.7 ± 1.15	1.24	89.133 ± 5.346	5.998
60	102.03 ± 0.76	0.74	109.167 ± 7.081	6.487
90	102.150 ± 0.071	0.069	125.233 ± 7.022	5.607
120	107.9 ± 4.078	3.7798	132.767 ± 6.732	5.071

Table 6: Drug release versus time profile for sutherlandin B from liposomes of FDAE Sutherlandia at PH 1.2 and 6.8

	Percentage Sutherlandin B released at pH 1.2		Percentage sutherlandin B released at pH 6.8	
Time (minutes)	**AVE ±SD**	**%CV**	**AVE ±SD**	**%CV**
0	0 ± 0	0	0 ± 0	0
5	130.733 ± 21.150	16.178	101.667 ± 19.19	18.883
15	131.867 ± 30.033	22.775	120.800 ± 9.180	7.600
30	132.050 ± 2.475	1.874	138.400 ± 4.004	2.893
60	133.400 ± 0.424	0.318	170.867 ± 5.865	3.433
90	135.600 ± 2.546	1.877	194.000 ± 1.414	0.729
120	149.800 ± 4.386	2.928	195.400 ± 9.334	4.777

Table 7: Drug release versus time profile data for sutherlandin C from liposomes of FDAE Sutherlandia at PH 1.2 and 6.8

	Percentage sutherlandin C released at pH 1.2		Percentage sutherlandin C released at pH 6.8	
Time (minutes)	**AVE ± SD**	**%CV**	**AVE ± SD**	**%CV**
0	0 ± 0	0	0 ± 0	0
5	175.200 ± 1.473	0.841	149.100 ± 0.173	0.116
15	181.633 ± 42.812	23.571	151.000 ± 0.000	0.000
30	195.100 ± 1.493	0.765	201.933 ± 0.709	0.351
60	216.067 ± 0.833	0.385	241.067 ± 0.115	0.048
90	220.533 ± 0.231	0.105	241.267 ± 18.3	7.585
120	231.967 ± 1.531	0.660	265.100 ± 0.529	0.200

Table 8: Drug release versus time profile for sutherlandin D from liposomes of FDAE Sutherlandia at PH 1.2 and 6.8

	Percentage Sutherlandin D released at pH 1.2		Percentage Sutherlandin D released at pH 6.8	
Time (minutes)	**AVE ± SD**	**%CV**	**AVE ± SD**	**%CV**
0	0 ± 0	0	0 ± 0	0
5	78.833 ± 2.237	2.837	115.900 ± 0.141	0.122
15	90.933 ± 24.194	26.607	114.550 ± 2.051	1.790
30	91.0 ± 1.947	2.139	162.500 ± 3.704	2.279
60	83.067 ±2.150	2.589	179.000 ±0.000	0.000
90	84.533 ± 1.361	1.610	173.667 ± 2.517	1.449
120	105.200 ± 1.970	1.872	204.367 ± 1.704	0.834

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