

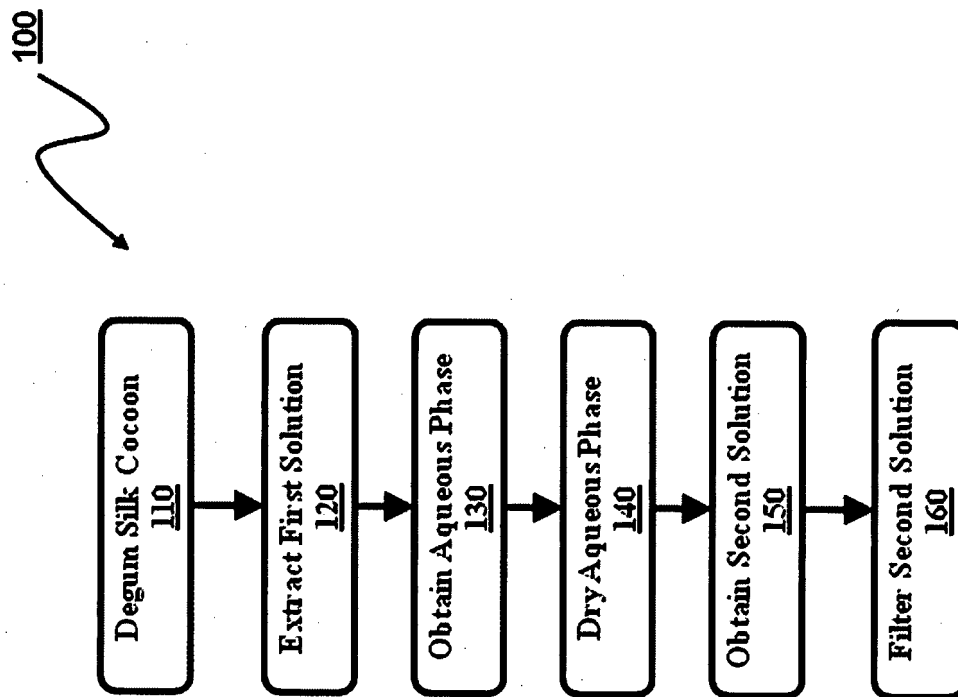


FIG. 1

Sample	$\lambda_{\max}$ (nm)	%III/II ^c		Lutein content ^a			
		I ^b	II	III	wet basis		dry basis
					(mg/100g)	(%by wt.)	(mg/100g)
S1	(420) 443 469	15 ^a	20.338 ^c ± 1.516	0.0203 ^c ± 0.0015	22.528 ^c ± 1.527	0.0225 ^c ± 0.0017	0.0225 ^c ± 0.0017
S2	(420) 443 469	11 ^d	23.787 ^{ab} ± 2.592	0.0238 ^{ab} ± 0.0026	26.348 ^{ab} ± 2.611	0.0264 ^{ab} ± 0.0029	0.0264 ^{ab} ± 0.0029
S3	(421) 442 469	13 ^c	22.751 ^b ± 1.792	0.0228 ^b ± 0.0018	25.200 ^b ± 1.805	0.0252 ^b ± 0.0020	0.0252 ^b ± 0.0020
S4	(420) 442 469	13 ^{bc}	12.253 ^e ± 0.899	0.0123 ^e ± 0.0009	13.572 ^e ± 0.905	0.0136 ^e ± 0.0010	0.0136 ^e ± 0.0010
S5	(421) 443 469	14 ^{ab}	15.176 ^d ± 0.939	0.0152 ^d ± 0.0009	16.810 ^d ± 0.946	0.0168 ^d ± 0.0010	0.0168 ^d ± 0.0010
S6	(419) 442 467	12 ^c	5.114 ^f ± 0.126	0.0051 ^f ± 0.0001	5.664 ^f ± 0.127	0.0057 ^f ± 0.0001	0.0057 ^f ± 0.0001
S7	(420) 443 469	13 ^c	24.316 ^a ± 0.625	0.0243 ^a ± 0.0006	26.934 ^a ± 0.630	0.0269 ^a ± 0.0007	0.0269 ^a ± 0.0007

^a Average of triplicate determinations ± standard deviation. ^b Values in parentheses represent shoulder. ^c %III/II represents the spectral fine structure, the shape of the spectrum. Yellow silk cocoons were degummed at 121°C for 15 min and then extracted with (S1) hexane/ethanol (3:4, v/v), (S2) hexane/acetone (5:3, v/v), (S3) hexane/acetone/ethanol (3:1:2, v/v/v), (S4) hexane/ethyl acetate (1:1, v/v), (S5) ethyl acetate (100%), (S6) hexane (100%), and (S7) hexane/ethanol/ethyl acetate (3:2:1, v/v/v). Different letters on the same column indicate significant differences ($p \leq 0.05$).

FIG. 2

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Temp.	Time (min)	Degumming solution ^a					Degummed cocoons ^a				
		Total solid (%by wt.)		Protein content		(mg/100ml)	Lutein content		(mg/100g)	Lutein content (%dry basis)	
		degumming solution	cocoons	(g/100ml)	(%dry basis)		(mg/100g)	cocoons wt.			total solid
85	30	0.11 ^j ± 0.01	3.82 ^j ± 0.17	0.094 ^e ± 0.015	3.468 ^e ± 0.550	0.0006 ^j ± 0.0001	0.113 ⁱ ± 0.013	0.00011 ⁱ ± 0.00001	0.00053 ⁱ ± 0.00002	46.877 ^a ± 1.355	0.0516 ^a ± 0.0015
	60	0.13 ^j ± 0.01	4.23 ^j ± 0.29	0.133 ^e ± 0.023	4.923 ^e ± 0.861	0.0002 ^j ± 0.0001	0.041 ⁱ ± 0.017	0.00004 ⁱ ± 0.00002	0.00016 ⁱ ± 0.00002	45.269 ^b ± 1.004	0.0498 ^b ± 0.0011
	90	0.12 ^j ± 0.00	3.99 ^j ± 0.13	0.071 ^e ± 0.028	2.622 ^e ± 1.047	0.0002 ^j ± 0.0001	0.037 ⁱ ± 0.013	0.00004 ⁱ ± 0.00001	0.00017 ⁱ ± 0.00001	44.188 ^c ± 1.410	0.0486 ^c ± 0.0016
	120	0.13 ^j ± 0.01	4.28 ^j ± 0.26	0.118 ^e ± 0.017	4.367 ^e ± 0.612	0.0002 ^j ± 0.0001	0.037 ⁱ ± 0.011	0.00004 ⁱ ± 0.00001	0.00015 ⁱ ± 0.00001	41.859 ^d ± 1.188	0.0460 ^d ± 0.0013
105	15	0.41 ^h ± 0.02	13.80 ^h ± 0.68	0.418 ^d ± 0.070	15.442 ^d ± 2.590	0.0403 ^e ± 0.0099	9.110 ^e ± 0.737	0.00911 ^e ± 0.00074	0.00959 ^e ± 0.00266	29.297 ^e ± 2.450	0.0322 ^e ± 0.0027
	30	0.54 ^g ± 0.02	17.97 ^g ± 0.54	0.542 ^c ± 0.049	20.000 ^c ± 1.800	0.0780 ^d ± 0.0050	14.372 ^d ± 0.893	0.01437 ^d ± 0.00089	0.01467 ^b ± 0.00122	26.979 ^f ± 0.641	0.0297 ^f ± 0.0007
	60	0.55 ^f ± 0.01	18.48 ^f ± 0.48	0.808 ^b ± 0.142	29.851 ^b ± 5.249	0.1010 ^c ± 0.0064	18.593 ^c ± 1.201	0.01859 ^c ± 0.00120	0.01808 ^a ± 0.00122	20.198 ⁱ ± 0.372	0.0222 ⁱ ± 0.0004
	90	0.64 ^e ± 0.02	21.30 ^e ± 0.61	1.004 ^a ± 0.084	37.054 ^a ± 3.100	0.1157 ^a ± 0.0029	21.328 ^a ± 0.548	0.02133 ^a ± 0.00055	0.01812 ^a ± 0.00051	18.551 ^j ± 0.739	0.0204 ^j ± 0.0008
120	0.69 ^d ± 0.02	22.85 ^d ± 0.58	0.996 ^a ± 0.062	36.786 ^a ± 2.272	0.1072 ^b ± 0.0028	0.1072 ^b ± 0.0028	19.748 ^b ± 0.571	0.01975 ^b ± 0.00057	0.01572 ^b ± 0.00051	18.649 ^j ± 0.887	0.0205 ^j ± 0.0010
121	15	0.71 ^c ± 0.01	23.58 ^c ± 0.44	0.803 ^b ± 0.075	29.651 ^b ± 2.780	0.0524 ^e ± 0.0020	9.652 ^e ± 0.360	0.00965 ^e ± 0.00036	0.00737 ^d ± 0.00028	25.633 ^g ± 0.550	0.0282 ^g ± 0.0006
	30	0.74 ^b ± 0.02	24.51 ^b ± 0.51	0.837 ^b ± 0.099	30.891 ^b ± 3.656	0.0515 ^e ± 0.0040	9.471 ^e ± 0.729	0.00947 ^e ± 0.00073	0.00706 ^d ± 0.00012	25.396 ^g ± 0.825	0.0279 ^g ± 0.0009
	60	0.75 ^a ± 0.01	24.90 ^a ± 0.39	0.997 ^a ± 0.083	36.800 ^a ± 3.077	0.0460 ^f ± 0.0012	8.466 ^f ± 0.216	0.00847 ^f ± 0.00022	0.00616 ^d ± 0.00014	25.021 ^h ± 0.559	0.0275 ^h ± 0.0006
	90	0.75 ^a ± 0.02	25.11 ^a ± 0.83	0.979 ^a ± 0.079	36.145 ^a ± 2.935	0.0307 ^h ± 0.0077	5.650 ^g ± 1.421	0.00565 ^g ± 0.00142	0.00409 ^e ± 0.00117	23.457 ^h ± 1.066	0.0258 ^h ± 0.0012
120	0.76 ^a ± 0.02	25.17 ^a ± 0.78	0.959 ^a ± 0.106	35.405 ^a ± 3.919	0.0266 ⁱ ± 0.0034	0.0266 ⁱ ± 0.0034	4.878 ^h ± 0.612	0.00488 ^h ± 0.00061	0.00353 ^e ± 0.00050	22.833 ^h ± 0.296	0.0251 ^h ± 0.0003
RT ^b	6	-	-	-	-	-	-	-	-	0.220 ^k ± 0.026	0.00022 ^k ± 0.00003
	6	-	-	-	-	-	-	-	-	0.220 ^k ± 0.041	0.00022 ^k ± 0.00004
	48	-	-	-	-	-	-	-	-	0.227 ^k ± 0.030	0.00023 ^k ± 0.00003

^a Average of triplicate determinations ± standard deviation. ^b Extraction of pigments from raw silk cocoons at room temperature. Different letters on the same column indicate significant differences ($p \leq 0.05$).

FIG. 3

Temp. (°C)	Time (min)	Total lutein content ^a		Retention of lutein ^c			L/S Ratio ^b (mg/kg)	
		(mg/100g)	(% wt.)	(% _{cd})	(% _{tc})	(% _{total})	TP	TS
85	30	46.990 ^a ± 1.354	0.052 ^a ± 0.001	100.00	100.00	100.00	0.33	0.30
	60	45.310 ^b ± 1.014	0.050 ^b ± 0.001	96.57	96.57	96.42	0.08	0.10
	90	44.225 ^b ± 1.414	0.049 ^b ± 0.002	94.26	94.26	94.12	0.14	0.09
	120	41.896 ^c ± 1.192	0.046 ^c ± 0.001	89.30	89.30	89.16	0.08	0.09
105	15	38.407 ^e ± 2.738	0.041 ^e ± 0.003	100.00	62.50	81.73	5.90	6.60
	30	41.351 ^c ± 0.649	0.044 ^d ± 0.001	92.09	57.55	88.00	7.19	8.00
	60	38.791 ^{de} ± 1.165	0.041 ^e ± 0.001	68.94	43.09	82.55	6.23	10.06
	90	39.880 ^d ± 0.745	0.042 ^e ± 0.001	63.32	39.57	84.87	5.76	10.01
	120	38.397 ^e ± 0.584	0.040 ^e ± 0.001	63.66	39.78	81.71	5.37	8.64
121	15	35.285 ^f ± 0.824	0.038 ^f ± 0.001	100.00	54.68	75.09	3.26	4.09
	30	34.867 ^f ± 0.943	0.037 ^{fg} ± 0.001	99.07	54.18	74.20	3.07	3.86
	60	33.487 ^g ± 0.668	0.036 ^g ± 0.001	97.61	53.38	71.26	2.30	3.40
	90	29.106 ^h ± 1.003	0.031 ^h ± 0.001	91.51	50.04	61.94	1.56	2.25
	120	27.711 ⁱ ± 0.784	0.030 ⁱ ± 0.001	89.08	48.71	58.97	1.38	1.94

^a Total lutein content including in the degumming solution and the degummed cocoons were averaged from triplicate determinations ± standard deviation, in dry basis. ^b Values were calculated from the ration of lutein to total protein contents (TP) and total solids (TS) in 100 ml of the degumming solutions. ^c The amount of lutein extracting from the degummed cocoons represent in %remaining, compared to that of the shortest heating time of each temperature (%_{cd}), and the lowest temperature and time (%_{tc}); total lutein content in yellow silk cocoons (%_{total}) represents in %remaining comparing to that of the lowest temperature and time. Different letters on the same column indicate significant differences ($p \leq 0.05$).

FIG. 4

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Sample ^b	$\lambda_{\max}$ (nm)	%II/II	Lutein content			
			(mg/100g)		(%)	
			wet wt.	dry wt.	wet wt.	dry wt.
P1	445 473	41	46.559 $\pm$ 0.420	51.572 $\pm$ 1.338	0.04656 $\pm$ 0.00042	0.05157 $\pm$ 0.00047
P2	446 470	1	0.051 $\pm$ 0.006	0.057 $\pm$ 0.006	0.00005 $\pm$ 0.00001	0.00006 $\pm$ 0.00001
Total ^c			46.610 $\pm$ 0.426	51.628 $\pm$ 1.345	0.04661 $\pm$ 0.00043	0.05163 $\pm$ 0.00047

^a Average of triplicate determinations $\pm$ standard deviation. ^b Yellow cocoons in both parts of degummed cocoons (P1) and degumming solution (P2). ^c Total lutein content in yellow cocoons.

FIG. 5

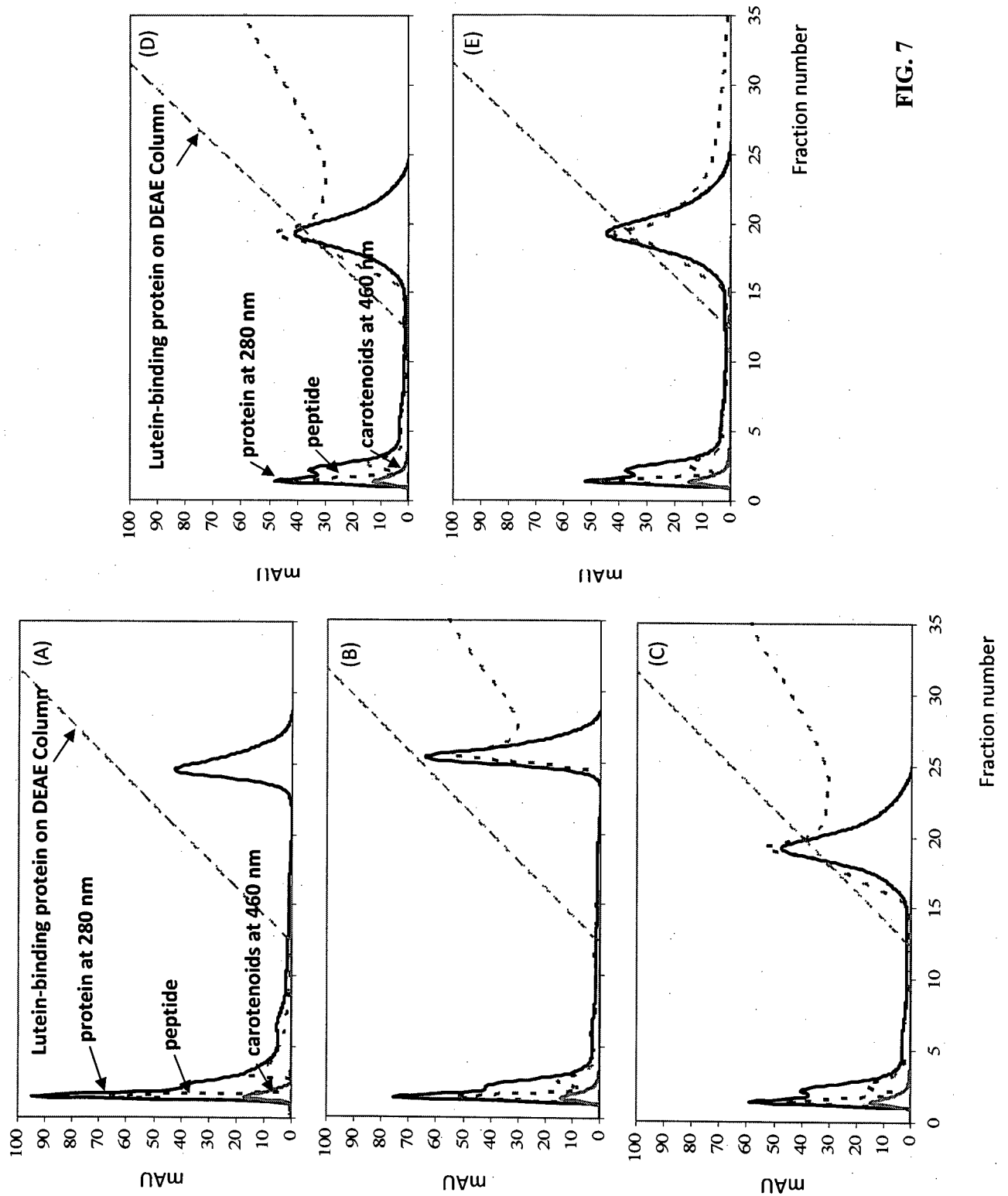
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Source	Distribution of major carotenoids (mole%) ^a							Lutein composition ^d		References
	zeaxanthin	lutein	cryptoxanthin	lyxopans	α -carotene	β -carotene	Neoxanthin/ Videanthin	mg/100g fresh wt.	mg/100g dry wt.	
Animal products:										
Yellow silk cocoons (<i>Bombyx mori</i>)	97	84	-	-	0	0	-	46.61	51.628	-
Egg yolk	89	54	4	0	0	0	8	3.766 ⁽¹¹⁾	0.723	(9), (11)
Fruits/vegetables:										
Kale, raw	-	-	-	-	-	-	-	39.550 ⁽¹⁾	-	(1), (3), (10)
"Winterbor" kale	-	-	-	-	-	-	-	15.10-6.90	71-112	(2)
Squash, pepper peel	-	-	-	-	-	-	-	30.180	-	(3)
Squash, pepper fresh	-	-	-	-	-	-	-	0.870	-	(3)
Spinach	47	47	19	4	0	16	14	11.940 ⁽¹⁾	133.7 ⁽⁴⁾ -34.9	(1), (3-6)
Leaf lettuce	15	15	36	0	16	0	33	2.635	-	(1)
Broccoli	22	22	49	0	0	27	3	2.445 ⁽¹⁾	1.553	(1), (10)
Summer squash	52	47	24	0	0	5	19	2.125	-	(1)
Brussel sprouts	29	27	39	0	0	11	20	1.590	-	(1)
Peas (green)	41	41	21	0	0	5	33	1.350	-	(1)
Corn	86	60	5	0	0	0	9	0.884 ⁽¹⁾	2.07 ⁽⁶⁾	(1), (5-6)
Green beans	0	0	28	0	0	0	72	0.640 ⁽¹⁾	0.453	(1), (10)
Potato, fresh	-	-	-	-	-	-	-	0.410-0.250	-	(3)
Carrots, baby	-	-	-	-	-	-	-	0.358	-	(1)
Carrot	2	2	0	0	43	55	0	0.298	-	(5)
Cabbage	-	-	-	-	-	-	-	0.310	-	(1)
Oranges	22	7	12	11	8	11	36	0.187	-	(1)
Papaya	-	-	-	-	-	-	-	0.075 ⁽¹⁾	0.044	(1), (10)
Peaches	13	5	8	0	10	50	20	0.04	-	(10)
Winter squash	-	-	-	-	-	-	-	0.038	-	(1)
Mango	18	2	4	6	0	20	52	0.020	-	(10)
Grapefruit, red	-	-	-	-	-	-	-	0.013	-	(1)
Tomatoes	6	6	0	82	0	12	0	0.130 ⁽¹⁾	0.050	(1), (5)
Pumpkin	49	49	0	0	0	21	30	-	-	-
Flowers:										
Marigold petals ^b	-	-	-	-	-	-	-	161-611	-	(7)
Marigold petals ^c	-	-	-	-	-	-	-	16.77-569.90	-	(8)
Marigold calyces ^c	-	-	-	-	-	-	-	0.38-18.60	-	(8)

^a The data from Sommerburg et al. (1998). ^b Lutein diesters in Chinese marigold flowers (*T. erecta*). ^c Lutein and lutein esters from marigold flowers, *Tagetes patula* and *T. erecta*. ^d Literature values refer to: (1), U.S. Department of Agriculture (1998); (2), Lefsrud et al. (2007); (3), Tsao and Yang (2006); (4), Liu, Perera and Suresh (2007); (5), Konings and Roomans (1997); (6), Aman et al. (2005); (7), Li et al. (2007); (8), Piccaglia, Marotti and Grandi (1998); (9), Handelman et al. (1999); (10), Humphries and Khachik (2003); and (11), Schlatterer and Breithaupt (2006).

FIG. 6

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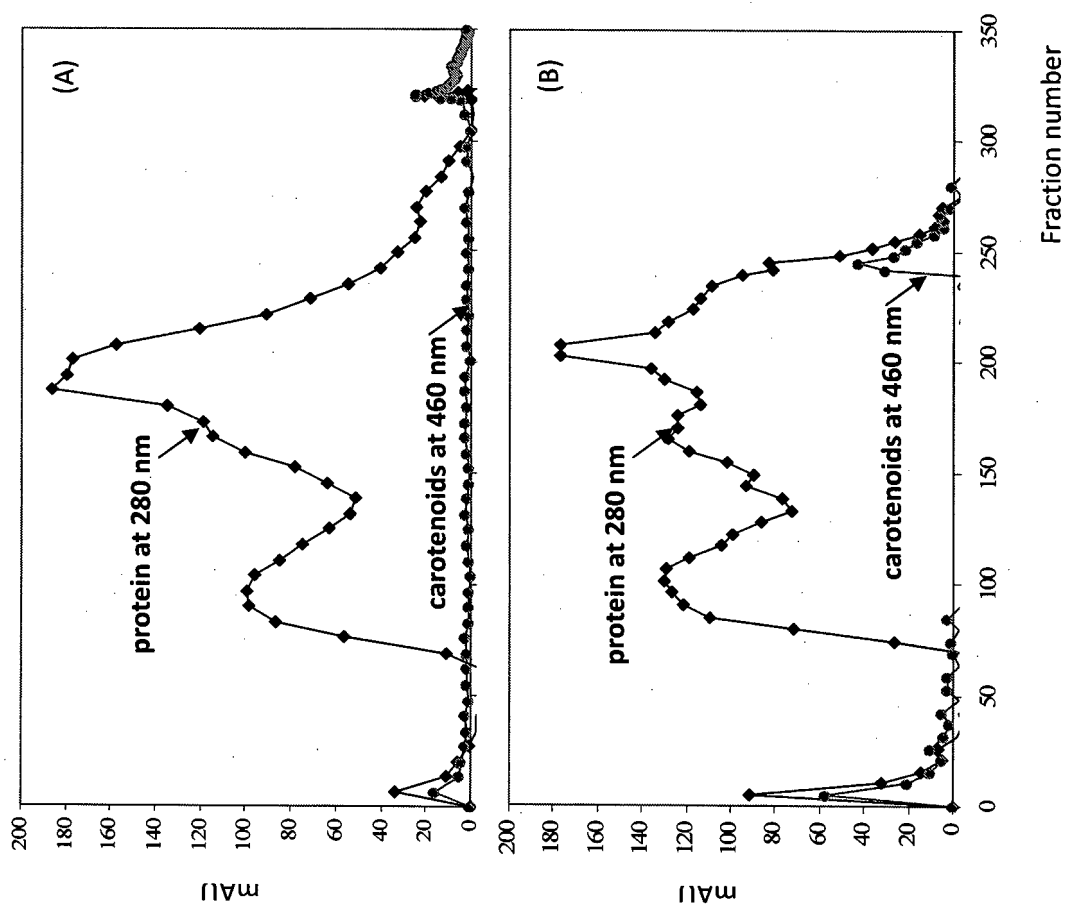


FIG. 8

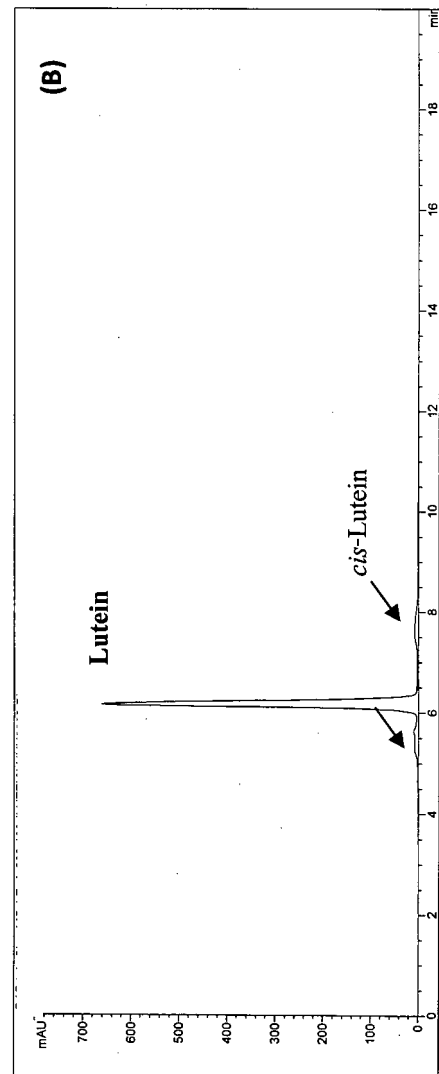
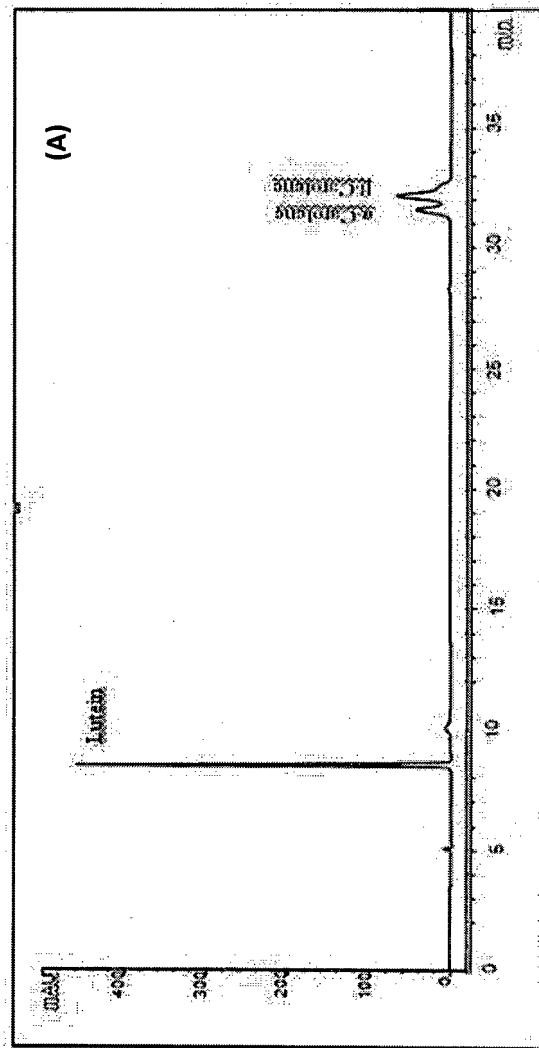


FIG. 9a

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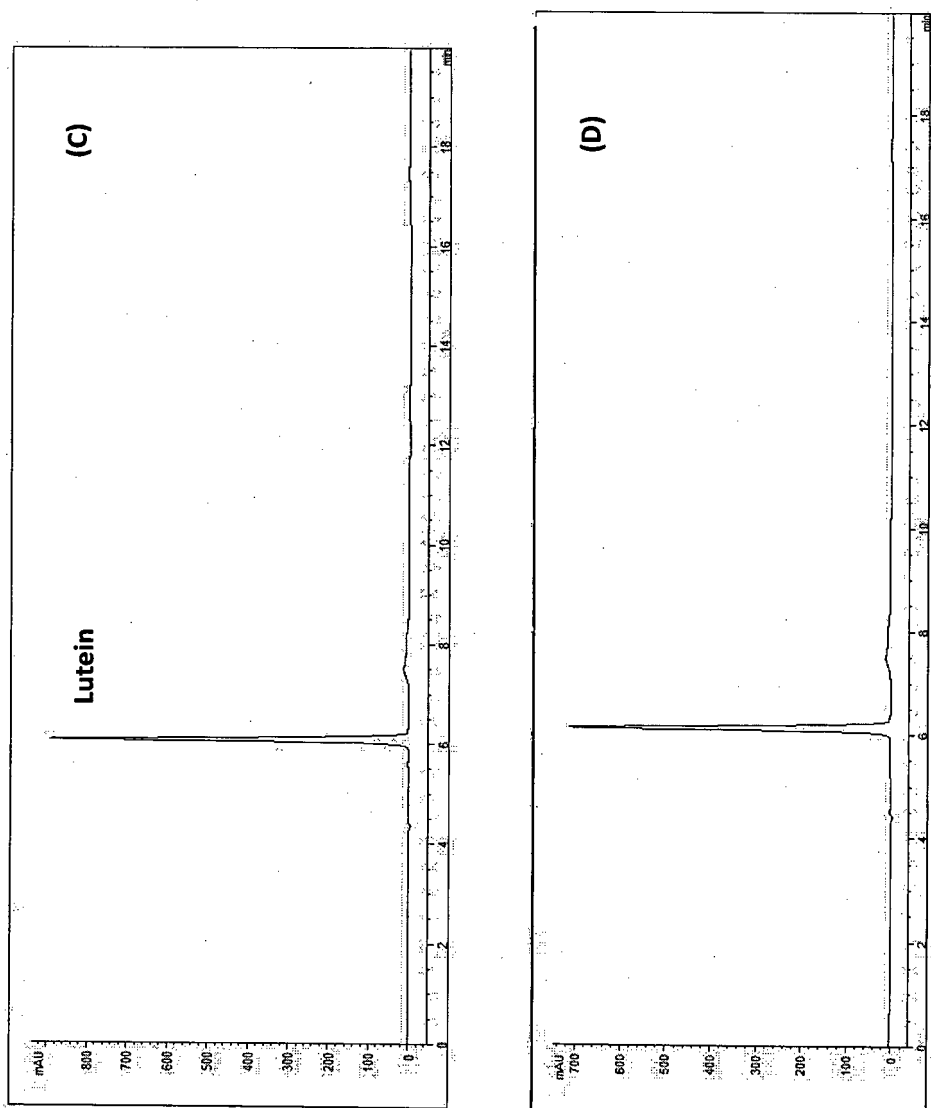


FIG. 9b

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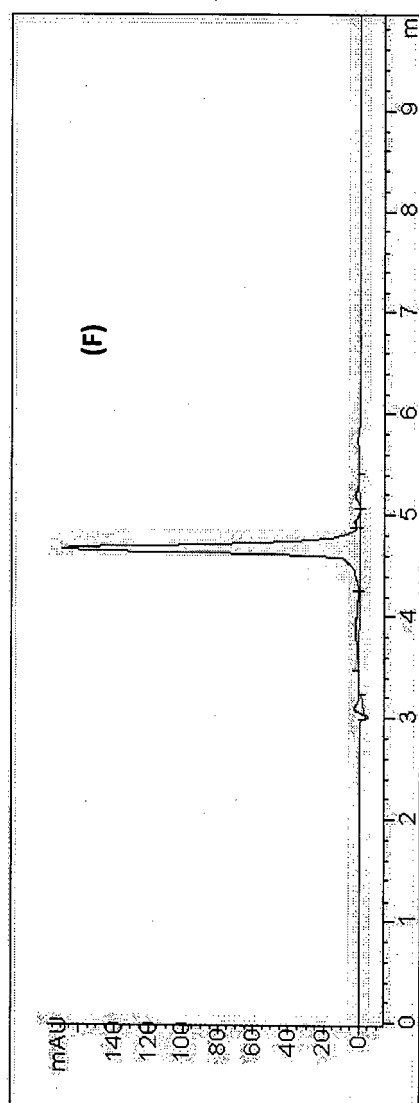
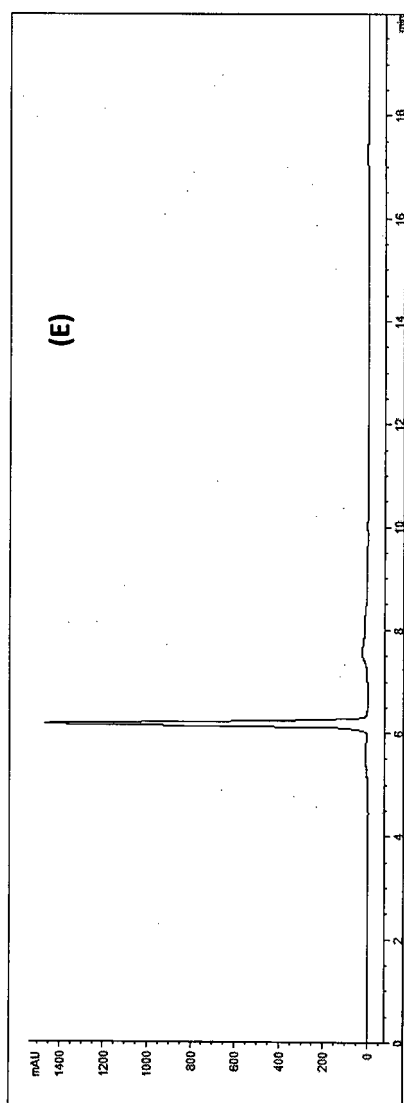


FIG. 9c

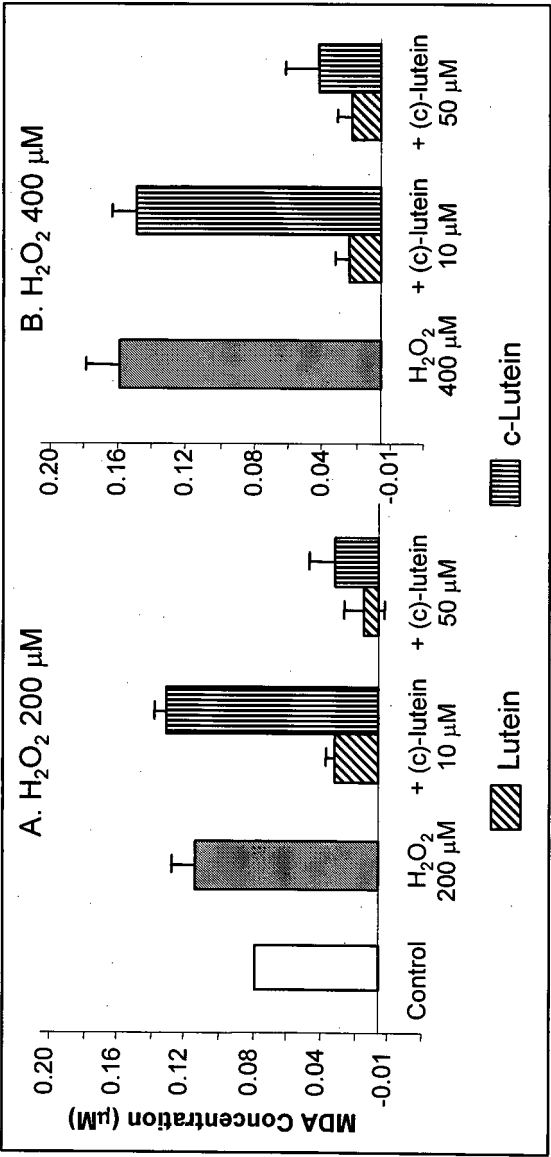


FIG. 10

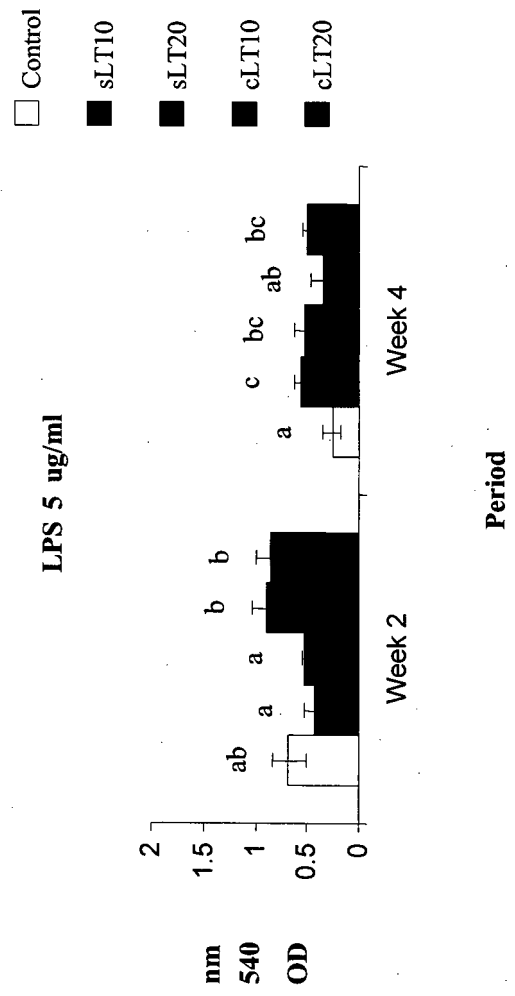
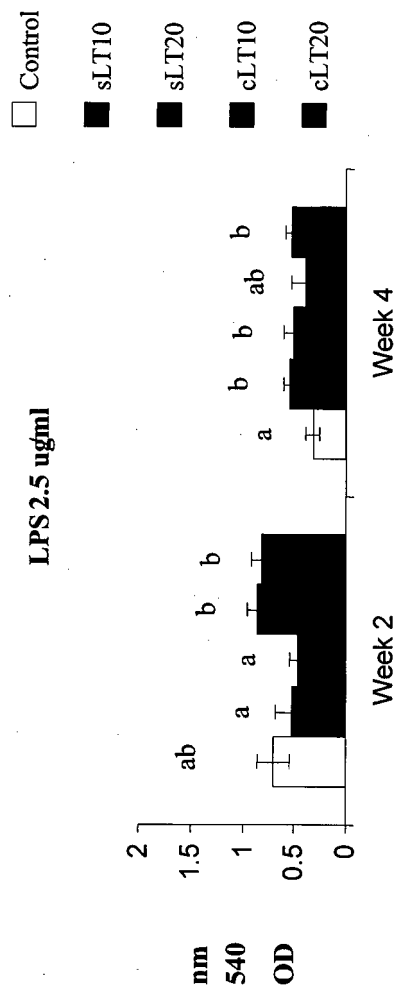


FIG. 11