Supplementary material

1D and 2D-HSQC NMR: two methods to distinguish and characterize heparin from different animal and tissue sources.

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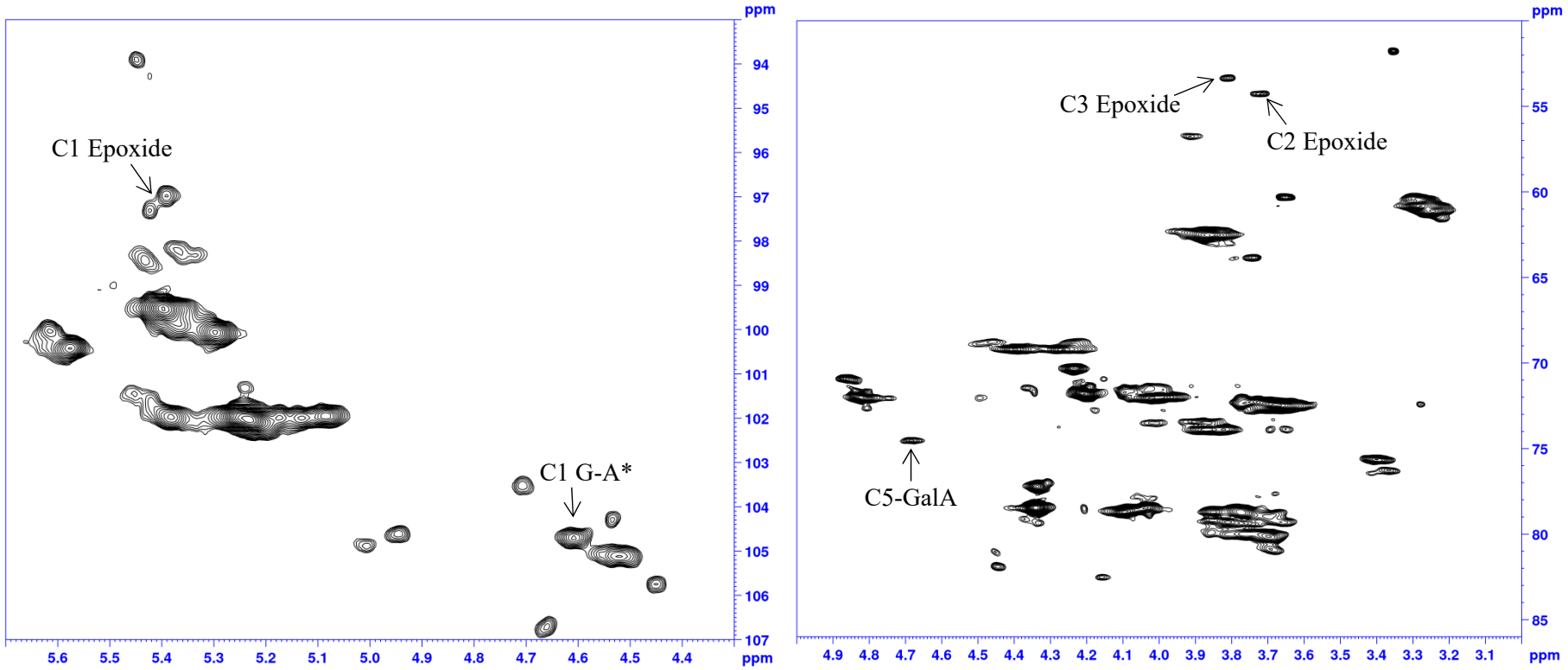

Figure S1 – HSQC spectrum of beef mucosa heparin containing epoxide and galacturonic acid residues. Expansions of the anomeric signals region (left) and of the ring signals (right).

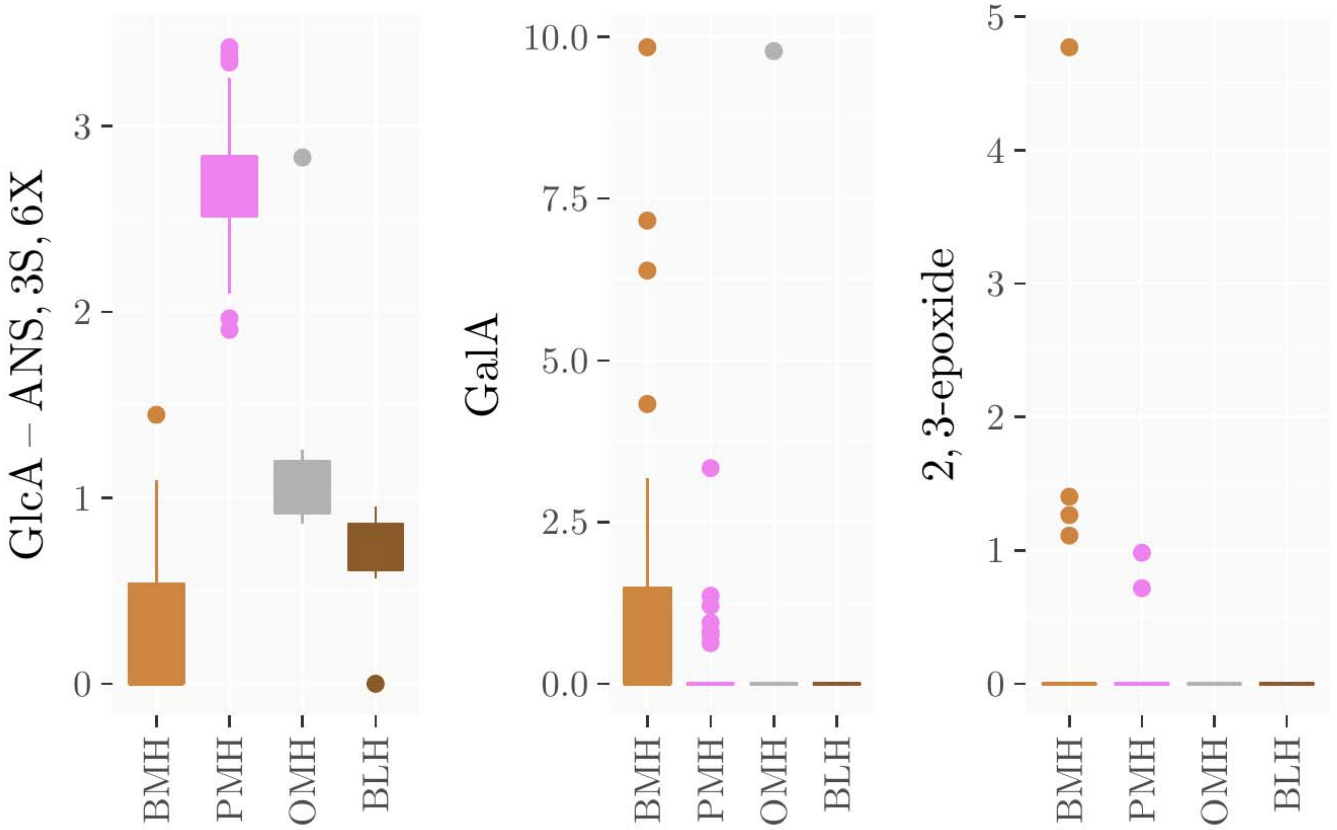

Figure S2- Boxplot of the HSQC content of G-($A_{NS,3S,6X}$), galacturonic acid and epoxide residues**.**

Table S1- Signal intensity ratio calculated on BMH spectra recorded at 500MHz

Sample	r (1:2)	r (3:2)
BMH-1	1.64	1.79
BMH-2	1.53	1.49
BMH-3	1.55	1.44
BMH-4	1.55	1.47
BMH-5	1.53	1.45
E1	1.53	1.98
F1	1.51	1.79
G1	1.48	1.86
H1	1.4	1.74
E2	1.73	2.56
F2	1.78	2.83
G2	1.86	2.73
K1	1.6	1.59
L1	1.48	1.44
M1	1.43	1.26
N1	1.38	1.29
O1	1.41	1.36
P1	1.48	1.33
Q1	1.52	1.55
R1	1.53	1.54
S1	1.6	1.48
O2	1.65	1.48
P2	1.64	1.49
Q2	1.62	1.44
R2	1.62	1.44
BMH-6	1.42	1.7
BMH-7	1.53	1.97
BMH-8	1.49	1.8
BMH-9	1.6	1.9
BMH-10	1.64	2.06
BMH-11	1.69	2.01
BMH-12	1.43	1.56
BMH-13	1.47	1.71
BMH-14	1.42	1.67
BMH-15	1.39	1.71
BMH-16	1.35	1.7
BMH-17	1.44	1.76
BMH-18	1.35	1.66
BMH-19	1.41	1.63
MIN	1.4	1.3
MAX	1.8	2.9

Table S2- Signal intensity ratio calculated on BMH spectra recorded at 600MHz

Sample	r (1:2)	r (3:2)
E1	1.54	2.06
F1	1.51	1.81
G1	1.48	1.85
H1	1.4	1.76
E2	1.73	2.92
F2	1.77	2.9
G2	1.84	2.81
K1	1.59	1.65
L1	1.48	1.37
M1	1.41	1.3
N1	1.37	1.28
O1	1.39	1.37
P1	1.47	1.38
Q1	1.51	1.52
R1	1.52	1.58
S1	1.59	1.5
O2	1.68	1.6
P2	1.68	1.6
Q2	1.66	1.59
E1	1.68	1.55
MIN	1.37	1.28
MAX	1.84	2.92

Table S3- Signal intensity ratio calculated on PMH spectra recorded at 500MHz

Sample	r (1:2)	r (3:2)
PMH-1	0.66	2
PMH-2	0.71	2.23
PMH-3	0.7	2.26
PMH-4	0.7	2.15
PMH-5	0.77	2.26
PMH-6	0.89	2.69
PMH-7	0.77	2.43
PMH-8	0.71	2.14
PMH-9	0.8	2.57
PMH-10	0.81	2.6
PMH-11	0.89	2.36
PMH-12	0.72	2
PMH-13	0.85	2.7
PMH-14	0.82	2.63
PMH-15	0.86	2.69
PMH-16	0.81	2.6
PMH-17	0.86	2.7
PMH-18	0.92	2.83
PMH-19	0.68	1.97
PMH-20	0.74	2.4
PMH-21	0.71	1.81
PMH-22	0.67	1.66
PMH-23	0.83	2.54
PMH-24	0.75	2.27
PMH-25	0.74	2.3
PMH-26	0.7	1.98
PMH-27	0.71	2.02
PMH-28	0.71	1.79
PMH-29	0.79	2.55
PMH-30	0.66	1.75
PMH-31	0.68	1.84
PMH-32	0.87	2.79
PMH-33	0.82	2.5
PMH-34	0.68	2
PMH-35	0.68	1.73
PMH-36	0.72	1.85
PMH-37	0.72	1.86
PMH-38	0.71	1.95
PMH-39	0.75	2.23
MIN	0.66	1.66
MAX	0.92	2.83

Table S4- Signal intensity ratio calculated on PMH spectra recorded at 600MHz

Sample	r (1:2)	r (3:2)
PMH-1	0.65	1.97
PMH-2	0.67	2.12
PMH-3	0.65	2.13
PMH-4	0.65	2.08
PMH-5	0.73	2.18
PMH-6	0.83	2.57
PMH-7	0.76	2.12
PMH-8	0.66	1.94
PMH-9	0.74	2.34
PMH-10	0.76	2.37
PMH-11	0.85	2.31
PMH-12	0.67	1.86
PMH-13	0.78	2.44
PMH-14	0.77	2.41
PMH-15	0.81	2.45
PMH-16	0.76	2.37
PMH-20	0.67	2.22
PMH-25	0.67	2.12
PMH-39	0.7	2.09
MIN	0.65	1.86
MAX	0.85	2.57

Table S5- Signal intensity ratio calculated on OMH spectra recorded at 500MHz (a) and 600MHz (b)

a)

Sample	r (1:2)	r (3:2)
OMH-1	0.54	0.96
OMH-2	0.48	1.01
OMH-3	0.52	1.02
OMH-4	0.48	0.98
OMH-5	0.54	1.23
OMH-6	0.52	1.21
MIN	0.48	0.96
MAX	0.54	1.23

b)

Sample	r (1:2)	r (3:2)
OMH-1	0.54	0.93
OMH-2	0.45	0.92
OMH-3	0.47	0.95
OMH-4	0.44	0.9
OMH-5	0.50	1.12
OMH-6	0.48	1.1
MIN	0.44	0.90
MAX	0.54	1.12

Table S6- Signal intensity ratio calculated on BLH spectra recorded at 500MHz (a) and 600MHz (b)

a)

Sample	r (1:2)	r (3:2)
BLH-1	0.29	0.18
BLH-2	0.34	0.31
BLH-3	0.34	0.32
BLH-4	0.38	0.4
BLH-5	0.36	0.36
BLH-6	0.38	0.38
BLH-7	0.37	0.4
MIN	0.29	0.18
MAX	0.38	0.40

b)

Sample	r (1:2)	r (3:2)
BLH-1	0.27	0.16
BLH-2	0.31	0.29
BLH-3	0.32	0.28
BLH-4	0.35	0.37
BLH-5	0.33	0.33
BLH-6	0.35	0.35
BLH-7	0.33	0.38
MIN	0.27	0.16
MAX	0.35	0.38

Table S7 - Signal ratios measured on spectra recorded with 16 or 8 scans. Six samples of the same PMH batch were prepared. S/N was calculated for the most intense peak of the 3.75-4.55 ppm region.

NS 16	**r(1:2)**	**r(3:2)**	**S/N**
PMH A	0.74	2.22	3458
PMH B	0.74	2.23	3447
PMH C	0.81	2.01	3369
PMH D	0.74	2.22	3392
PMH E	0.74	2.21	3321
PMH F	0.74	2.22	3328
mean	0.754	2.187	3385.8
Std	0.030	0.087	58.02
CV%	3.9	4.0	1.7
NS 8	**r(1:2)**	**r(3:2)**	
PMH A	0.75	2.23	2451
PMH B	0.75	2.22	2478
PMH C	0.82	2.01	2424
PMH D	0.75	2.16	2387
PMH E	0.75	2.21	2333
PMH F	0.74	2.23	2376
mean	0.758	2.177	2408.2
Std	0.029	0.085	53.1
CV%	3.8	3.9	2.2

Table S8 - Signal intensity ratio r (1:2) calculated on BMH spectra recorded in two different laboratories

Sample	r(1:2) Lab 1	r(1:2) Lab 2
E1	1.53	1.56
F1	1.51	1.55
G1	1.48	1.43
H1	1.40	1.43
E2	1.73	1.78
F2	1.78	1.75
G2	1.86	1.85
K1	1.60	1.59
L1	1.48	1.41
M1	1.43	1.42
N1	1.38	1.20
O1	1.41	1.40
P1	1.48	1.50
Q1	1.52	1.47
R1	1.53	1.53
S1	1.60	1.78
O2	1.65	1.65
P2	1.64	1.68
Q2	1.62	1.58
R2	1.62	1.41
min	1.38	1.20
max	1.86	1.85

Table S9 – Proton and carbon chemical shifts of signals integrated of the HSQC spectrum

Fragment	ν(F2) [ppm]	ν(F1) [ppm]
$^{2}A_{NS,6X}$	3.31	61.2
$^{2}A_{NS,3S,6X}$	3.44	59.4
$^{2}A_{NAc,6X}$	3.92	56.4
$^{2}A_{NH2,6X}$	3.92	56.9
$^{6}A_{NY,3X}$	3.87	62.6
$^{6}A_{NY,3X,6S}$	4.36	69.1
$^{1}A_{NS,6X}$-(G)	5.59	100.3
$^{1}A_{NS,3S,6X}$	99.0	5.52
$^{1}A_{NS,6X}$-(I_{2S}) + $^{1}A_{NAc}$-(G)	99.8	5.37
$^{1}A_{NS,6X}$-(I)	983	5.36
$^{1}A_{NAc,6X}$-($_{I2x}$)	96.5	5.15
$^{1}A_{NS,6X}$-aRed + $^{1}A_{NH2,6X}$	93.9	5.45
$^{1}A_{NAc,6X}$-aRed	93.4	5.21
$^{1}A_{NS,6X}$-(GalA) + ^{1}Unk	102.0	5.4
$^{1}I_{2S}$-($A_{NY',3X,6X}$) + ^{1}GalA	102.3	5.20
^{1}I-($A_{NY',6S}$)	104.9	5.02
^{1}I-($A_{NY'}$)	104.7	4.95
$^{1}G_{2S}$	103.7	4.70
^{1}G-($A_{NS,3S,6X}$)	103.9	4.62
^{1}G-($A_{NS,6X}$)	104.9	4.62
^{1}G-($A_{NAc,6X}$)	105.1	4.51
^{1}Gal-(Xyl)	104.3	4.54
^{1}Xyl-(Ser)	105.2	4.45
^{1}Xyl-(ox-Ser)	105.8	4.45
^{1}G-(Gal) + ^{1}Gal-(Gal)	106.7	4.66
^{5}GalA	74.5	4.70
^{1}2,3-epoxide	97.5	5.43
$^{1}I_{2S}$-($A_{NH2,6X}$)	101.3	5.25
$^{4}G_{NR}$	74.8	3.55
$^{3}G_{NR}$	78.0	3.54
$^{2}A_{NAc}$-ox	59.0	4.37

Table S10 -Molar percentual of glucosamine residues of 39 porcine heparin samples

Samples	ANH2,6x	ANAc,6x	ANS,3S,6x	ANS,6X	ANAc,6X-G	ANAc,6X-I	ANS,6X-G	ANS,6X-I	ANS,6X-I2S	ANS,6X-GalA	ANS,6X-Epox	ANAc,6XaRed	ANS,6XaRed	% 6S
PMH-1	< LOD	11.5	5.5	83.0	11.5	< LOD	9.0	9.9	59.1	4.3	< LOD	< LOD	0.8	81.1
PMH-2	< LOD	13.2	5.4	81.4	12.6	0.6	9.9	8.8	62.0	0.6	< LOD	< LOD	< LOD	79.1
PMH-3	< LOD	13.7	5.6	79.9	13.7	< LOD	9.9	7.7	60.5	1.3	< LOD	< LOD	< LOD	79.8
PMH-4	< LOD	13.2	5.1	81.7	13.2	< LOD	10.1	8.7	59.6	3.2	< LOD	< LOD	< LOD	79.0
PMH-5	< LOD	11.8	4.4	83.8	11.8	< LOD	9.7	8.5	63.4	2.2	< LOD	< LOD	< LOD	78.7
PMH-6	1.5	14.7	4.9	78.9	14.7	< LOD	9.5	8.8	59.9	1.0	< LOD	< LOD	< LOD	75.7
PMH-7	1.5	12.6	5.0	80.9	10.9	0.8	9.0	8.8	62.9	< LOD	< LOD	0.9	< LOD	77.8
PMH-8	1.0	12.9	5.5	80.6	12.9	< LOD	9.9	7.6	61.5	1.6	< LOD	< LOD	< LOD	77.4
PMH-9	1.6	13.3	4.8	80.3	12.3	1.1	9.2	8.2	62.8	< LOD	< LOD	< LOD	< LOD	77.1
PMH-10	1.6	14.3	4.9	79.3	14.3	< LOD	9.5	8.5	61.1	< LOD	< LOD	< LOD	< LOD	76.5
PMH-11	2.2	12.5	4.7	80.5	11.8	< LOD	10.4	9.0	60.0	2.3	1.0	0.8	< LOD	76.7
PMH-12	1.6	11.8	4.7	82.0	11.0	0.7	10.7	7.9	62.8	0.7	< LOD	< LOD	< LOD	78.5
PMH-13	1.9	14.0	4.5	79.6	13.2	0.8	9.5	8.3	60.0	1.2	< LOD	< LOD	< LOD	76.9
PMH-14	1.5	13.4	4.8	80.4	13.4	< LOD	10.4	8.6	60.2	1.0	< LOD	< LOD	< LOD	77.4
PMH-15	2.8	13.4	4.5	79.2	13.4	< LOD	8.5	8.8	63.2	< LOD	< LOD	< LOD	< LOD	76.3
PMH-16	1.4	13.9	4.6	80.2	13.9	< LOD	9.2	8.5	61.0	1.2	< LOD	< LOD	< LOD	76.1
PMH-17	2.1	12.8	5.2	80.0	12.8	< LOD	8.0	7.6	63.9	1.4	< LOD	< LOD	< LOD	76.8
PMH-18	1.8	15.1	5.0	78.2	14.3	0.8	8.3	8.8	61.1	< LOD	< LOD	< LOD	< LOD	75.0
PMH-19	1.7	11.5	5.3	81.5	11.5	< LOD	8.8	8.0	63.8	1.1	< LOD	< LOD	< LOD	79.6
PMH-20	1.9	13.6	5.7	78.9	13.6	< LOD	8.9	6.7	62.7	< LOD	< LOD	< LOD	< LOD	78.4
PMH-21	0.7	12.9	4.8	81.6	12.9	< LOD	10.1	9.4	61.7	< LOD	< LOD	< LOD	< LOD	77.4
PMH-22	< LOD	11.4	4.9	83.8	10.8	0.6	9.9	8.4	63.3	0.8	< LOD	< LOD	1.3	77.5
PMH-23	1.6	13.9	4.8	79.7	13.0	0.9	9.4	9.0	60.5	< LOD	< LOD	< LOD	0.8	74.7
PMH-24	1.2	13.7	4.1	81.1	11.5	0.6	10.3	8.7	59.0	2.0	< LOD	1.6	1.2	73.6
PMH-25	2.0	12.5	5.0	80.5	11.5	0.9	9.9	6.5	62.9	0.7	< LOD	< LOD	< LOD	77.1
PMH-26	0.6	12.3	5.0	82.1	11.6	0.7	10.3	6.9	63.7	0.8	< LOD	< LOD	< LOD	77.1
PMH-27	0.7	13.2	5.3	80.8	13.2	< LOD	9.7	8.1	62.0	0.6	< LOD	< LOD	< LOD	78.3
PMH-28	0.9	11.7	4.7	82.7	10.7	1.0	10.1	8.7	62.6	0.9	< LOD	< LOD	< LOD	76.7
PMH-29	1.0	13.7	4.8	80.5	11.8	0.8	9.9	8.5	63.1	< LOD	< LOD	1.0	< LOD	76.1
PMH-30	1.7	11.5	6.7	80.1	10.9	0.6	9.1	7.6	62.2	1.0	< LOD	< LOD	< LOD	79.3
PMH-31	1.6	12.2	5.7	80.6	11.4	0.8	9.2	8.4	61.6	1.4	< LOD	< LOD	< LOD	79.2
PMH-32	1.7	15.3	5.4	77.6	14.0	0.7	9.3	8.5	58.1	1.6	< LOD	0.7	< LOD	74.7
PMH-33	2.0	14.7	4.9	78.5	13.7	0.9	9.0	9.0	59.5	0.6	< LOD	< LOD	< LOD	77.3
PMH-34	2.4	10.0	5.4	82.2	9.3	0.7	9.0	8.1	63.9	1.2	< LOD	< LOD	< LOD	81.2
PMH-35	1.0	11.3	5.2	82.6	11.3	< LOD	9.4	9.3	60.0	2.5	0.8	< LOD	0.8	82.3
PMH-36	1.3	11.8	4.1	82.8	11.8	< LOD	9.9	7.9	61.0	3.4	< LOD	< LOD	0.7	76.8
PMH-37	1.3	11.2	4.1	83.4	10.0	0.6	9.8	9.2	60.3	3.6	< LOD	0.6	< LOD	77.1
PMH-38	1.1	11.1	3.8	84.0	11.1	< LOD	11.0	7.0	62.3	3.2	< LOD	< LOD	< LOD	76.7
PMH-39	2.0	12.8	5.1	80.1	12.2	0.6	9.3	8.5	61.8	0.6	< LOD	< LOD	< LOD	78.4

Table S11- Molar percentual of uronic acids residues of 39 porcine mucosa heparin samples

Samples	G2OH	G2S	I2OH	I2S	G-ANAc,6X	G-ANS,6X	G-ANS,3S,6X	I-ANY	I-ANY,6S	I2S-ANH2,6X	I2S-ANY,3X,6X	GalA	Epox
PMH-1	15.2	< LOD	8.8	72.7	5.4	6.4	3.4	2.2	6.6	< LOD	72.7	3.3	< LOD
PMH-2	15.5	< LOD	9.3	75.2	6.4	6.7	2.4	2.7	6.6	< LOD	75.2	< LOD	< LOD
PMH-3	14.8	< LOD	9.4	75.8	5.4	6.1	3.3	2.7	6.7	1.5	74.3	< LOD	< LOD
PMH-4	16.1	< LOD	8.9	75.0	7.1	6.4	2.6	2.6	6.3	< LOD	75.0	< LOD	< LOD
PMH-5	15.1	< LOD	8.9	75.3	6.3	6.2	2.6	2.2	6.6	< LOD	74.6	0.8	< LOD
PMH-6	15.9	< LOD	9.2	74.9	6.8	6.4	2.7	2.6	6.6	1.6	73.4	< LOD	< LOD
PMH-7	14.0	< LOD	9.9	76.2	5.3	5.8	2.9	3.2	6.7	1.9	74.3	< LOD	< LOD
PMH-8	15.8	< LOD	8.7	75.5	7.0	6.0	2.8	3.0	5.7	1.4	74.2	< LOD	< LOD
PMH-9	14.9	< LOD	9.4	75.8	5.8	6.6	2.5	2.6	6.8	1.7	74.1	< LOD	< LOD
PMH-10	14.8	< LOD	8.6	76.5	6.3	5.8	2.7	2.5	6.2	1.7	74.8	< LOD	< LOD
PMH-11	16.3	< LOD	9.2	72.6	7.1	6.9	2.3	2.7	6.5	1.5	71.1	0.9	1.0
PMH-12	14.7	< LOD	7.7	77.7	5.4	6.7	2.5	2.3	5.4	1.8	75.9	< LOD	< LOD
PMH-13	14.8	< LOD	9.8	75.4	5.9	5.6	3.3	2.8	7.0	2.2	73.2	< LOD	< LOD
PMH-14	15.4	< LOD	9.4	75.2	6.3	6.5	2.6	2.7	6.7	1.6	73.6	< LOD	< LOD
PMH-15	14.1	< LOD	10.0	75.9	5.7	5.8	2.6	3.1	6.9	2.1	73.7	< LOD	< LOD
PMH-16	15.9	< LOD	9.7	74.4	6.9	6.3	2.7	3.2	6.5	1.8	72.7	< LOD	< LOD
PMH-17	15.1	< LOD	9.2	75.7	5.6	6.6	2.9	2.5	6.7	2.0	73.7	< LOD	< LOD
PMH-18	16.4	< LOD	9.7	73.9	6.1	6.9	3.4	3.2	6.6	1.7	72.2	< LOD	< LOD
PMH-19	14.4	< LOD	7.9	77.7	6.5	5.3	2.7	2.4	5.5	1.7	76.0	< LOD	< LOD
PMH-20	13.1	< LOD	9.2	77.8	4.6	5.1	3.4	3.4	5.8	2.2	75.6	< LOD	< LOD
PMH-21	15.4	< LOD	7.7	77.0	5.9	6.8	2.7	2.4	5.3	1.1	75.9	< LOD	< LOD
PMH-22	12.9	< LOD	7.5	79.6	4.4	6.3	2.1	2.4	5.1	1.0	78.7	< LOD	< LOD
PMH-23	16.1	< LOD	8.7	75.2	6.5	7.1	2.6	2.4	6.3	2.3	72.9	< LOD	< LOD
PMH-24	16.7	< LOD	9.7	73.1	7.2	6.6	2.8	3.2	6.5	1.6	71.5	0.6	< LOD
PMH-25	13.3	< LOD	9.4	77.3	4.6	5.8	2.9	3.1	6.3	2.0	75.3	< LOD	< LOD
PMH-26	15.3	< LOD	7.9	76.8	6.7	5.8	2.8	2.7	5.2	0.9	75.9	< LOD	< LOD
PMH-27	14.5	< LOD	7.9	77.6	6.0	6.2	2.3	2.7	5.2	0.7	76.9	< LOD	< LOD
PMH-28	14.9	< LOD	7.4	77.7	6.0	6.6	2.3	2.2	5.2	1.3	76.4	< LOD	< LOD
PMH-29	13.4	< LOD	9.2	77.4	4.8	6.8	1.9	2.6	6.6	1.0	76.4	< LOD	< LOD
PMH-30	14.9	< LOD	7.3	77.8	5.6	6.5	2.8	2.1	5.2	1.5	76.3	< LOD	< LOD
PMH-31	14.4	< LOD	7.3	78.3	6.4	5.4	2.5	2.3	4.9	1.6	76.7	< LOD	< LOD
PMH-32	17.5	< LOD	9.3	73.2	7.9	6.6	3.0	2.7	6.6	1.7	71.6	< LOD	< LOD
PMH-33	16.5	< LOD	9.4	74.1	6.6	7.0	3.0	2.6	6.8	2.0	72.1	< LOD	< LOD
PMH-34	13.6	< LOD	8.3	78.1	4.6	6.5	2.6	2.6	5.7	2.2	75.9	< LOD	< LOD
PMH-35	13.0	< LOD	7.8	77.3	5.0	5.4	2.6	2.1	5.7	1.4	75.9	1.2	0.7
PMH-36	14.5	< LOD	7.1	77.6	6.1	6.2	2.3	2.5	4.6	1.4	76.2	0.8	< LOD
PMH-37	14.8	< LOD	7.3	76.5	5.7	6.9	2.2	2.3	5.0	1.4	75.1	1.4	< LOD
PMH-38	15.2	< LOD	7.4	77.4	6.6	6.7	2.0	2.5	4.9	1.1	76.4	< LOD	< LOD
PMH-39	15.1	< LOD	9.0	76.0	6.0	6.3	2.8	2.1	6.8	2.1	73.9	< LOD	< LOD

Table S12 - Linkage region and sulfation degree of 39 porcine mucosa heparin samples

Samples	LR	%ox Ser	SDEG
PMH-1	3.1	59.0	2.48
PMH-2	3.8	70.0	2.46
PMH-3	4.3	66.4	2.47
PMH-4	3.8	79.7	2.46
PMH-5	3.8	55.1	2.47
PMH-6	5.1	100.0	2.39
PMH-7	4.0	0.0	2.45
PMH-8	3.8	100.0	2.44
PMH-9	6.2	0.0	2.43
PMH-10	5.3	0.0	2.42
PMH-11	3.9	0.0	2.39
PMH-12	4.1	47.3	2.48
PMH-13	5.5	0.0	2.41
PMH-14	4.9	0.0	2.43
PMH-15	6.4	0.0	2.40
PMH-16	5.2	24.0	2.40
PMH-17	6.0	74.0	2.43
PMH-18	6.2	100.0	2.37
PMH-19	3.5	100.0	2.49
PMH-20	6.1	0.0	2.46
PMH-21	2.3	57.6	2.45
PMH-22	1.4	0.0	2.51
PMH-23	5.2	100.0	2.39
PMH-24	3.2	36.0	2.36
PMH-25	5.9	0.0	2.45
PMH-26	2.1	100.0	2.46
PMH-27	2.7	100.0	2.47
PMH-28	2.2	52.2	2.47
PMH-29	5.7	36.7	2.44
PMH-30	2.8	100.0	2.51
PMH-31	3.3	100.0	2.49
PMH-32	5.0	79.8	2.36
PMH-33	5.2	100.0	2.40
PMH-34	4.3	0.0	2.52
PMH-35	2.5	100.0	2.53
PMH-36	3.6	100.0	2.45
PMH-37	2.6	76.5	2.45
PMH-38	3.7	70.0	2.46
PMH-39	4.6	100.0	2.45

Table S13 - Molar percentual of glucosamine residues of 39 bovine mucosa heparin samples

Sample	ANH2,6x	ANAc,6x	ANS,3S,6x	ANS,6X	ANAc,6X-G	ANAc,6X-I	ANS,6X-G	ANS,6X-I	ANS,6X-I2S	ANS,6X-GalA	ANS,6X-Epox	ANAc,6XaRed	ANS,6XaRed	% 6S
BMH-1	< LOD	6.8	2.1	91.2	6.8	< LOD	17.2	4.2	67.4	1.0	< LOD	< LOD	1.4	49.6
BMH-2	< LOD	7.2	1.3	91.6	7.2	< LOD	17.1	3.2	70.2	< LOD	< LOD	< LOD	1.1	51.2
BMH-3	0.6	5.8	1.1	92.5	5.3	< LOD	15.3	3.6	73.3	< LOD	< LOD	0.5	< LOD	50.6
BMH-4	< LOD	6.0	1.6	92.4	6.0	< LOD	15.3	3.9	73.2	< LOD	< LOD	< LOD	< LOD	49.8
BMH-5	0.8	6.3	1.3	91.5	6.3	< LOD	15.4	3.8	71.1	0.6	< LOD	< LOD	0.6	50.9
E1	< LOD	8.7	1.9	89.5	8.7	< LOD	15.9	4.4	67.2	2.0	< LOD	< LOD	< LOD	52.5
F1	< LOD	7.5	1.4	91.0	6.6	< LOD	17.3	5.3	67.0	1.5	< LOD	1.0	< LOD	52.0
G1	< LOD	7.0	1.8	91.2	5.9	< LOD	15.5	4.1	69.8	1.2	< LOD	1.1	0.6	53.1
H1	< LOD	8.0	1.8	90.2	7.1	< LOD	15.8	4.9	68.5	0.9	< LOD	0.9	< LOD	54.8
E2	< LOD	11.3	2.0	86.8	10.5	< LOD	16.4	4.7	63.9	< LOD	< LOD	0.8	1.8	49.2
F2	1.8	11.0	1.8	85.5	10.3	< LOD	16.5	5.0	63.1	0.8	< LOD	0.7	< LOD	49.8
G2	1.0	11.8	1.5	85.6	11.0	< LOD	16.3	5.2	61.9	1.0	< LOD	0.8	1.2	48.1
K1	0.8	8.0	1.3	89.9	8.0	< LOD	15.5	3.8	70.1	0.5	< LOD	< LOD	< LOD	50.4
L1	1.3	6.4	1.6	90.7	5.7	< LOD	16.1	4.9	68.3	1.4	< LOD	0.7	< LOD	52.3
M1	< LOD	5.9	1.9	92.2	5.9	< LOD	16.8	3.5	68.8	1.3	< LOD	< LOD	1.7	52.7
N1	0.8	5.6	2.4	91.3	5.0	< LOD	15.7	3.9	70.0	0.6	< LOD	0.6	1.2	54.1
O1	0.9	5.5	1.6	92.0	4.9	< LOD	15.6	3.4	71.4	0.7	< LOD	0.7	0.9	54.0
P1	< LOD	5.8	1.4	92.8	5.8	< LOD	14.9	3.1	72.9	0.6	< LOD	< LOD	1.4	50.4
Q1	1.1	7.2	1.1	90.6	7.2	< LOD	17.0	2.9	70.5	< LOD	< LOD	< LOD	< LOD	50.9
R1	0.7	6.7	1.7	91.0	6.7	< LOD	15.7	3.8	69.7	1.2	< LOD	< LOD	< LOD	51.1
S1	< LOD	6.2	1.6	92.2	6.2	< LOD	15.9	3.3	71.3	< LOD	< LOD	< LOD	1.7	48.8
O2	< LOD	6.1	2.0	91.3	6.1	< LOD	17.0	4.7	58.1	8.9	1.3	< LOD	1.3	50.5
P2	< LOD	6.0	1.1	92.9	6.0	< LOD	17.6	4.4	59.4	8.1	1.5	< LOD	2.0	49.8
Q2	< LOD	5.1	1.4	92.9	5.1	< LOD	17.2	4.1	60.5	8.7	1.2	< LOD	1.3	50.5
R2	1.4	5.5	2.0	91.1	5.5	< LOD	16.4	5.1	51.0	13.7	5.1	< LOD	< LOD	51.2
BMH-6	< LOD	6.7	2.9	90.4	5.8	< LOD	16.4	5.1	66.8	0.8	< LOD	0.9	1.2	54.6
BMH-7	1.3	8.8	2.0	87.9	8.8	< LOD	15.1	5.0	66.4	1.4	< LOD	< LOD	< LOD	52.4
BMH-8	1.0	7.3	1.8	90.0	7.3	< LOD	15.4	4.3	68.1	1.8	< LOD	< LOD	< LOD	53.5
BMH-9	< LOD	7.6	2.4	90.1	6.6	< LOD	15.9	4.2	66.3	2.4	< LOD	1.0	1.3	50.2
BMH-10	1.1	9.0	2.0	87.9	9.0	< LOD	15.9	4.6	65.8	1.8	< LOD	< LOD	< LOD	49.7
BMH-11	< LOD	8.6	1.2	90.3	8.6	< LOD	17.0	3.7	67.0	1.2	< LOD	< LOD	1.4	47.1
BMH-12	0.7	6.0	1.7	91.6	5.1	< LOD	15.2	4.4	65.7	5.7	< LOD	0.9	0.6	54.9
BMH-13	< LOD	6.9	1.8	91.3	6.1	< LOD	15.1	4.8	64.4	5.8	< LOD	0.8	1.1	53.4
BMH-14	< LOD	7.5	2.3	90.3	6.6	< LOD	14.7	4.5	64.8	4.9	< LOD	0.9	1.4	55.0
BMH-15	0.8	7.8	2.3	89.2	7.8	< LOD	16.3	3.8	63.4	6.5	< LOD	< LOD	< LOD	55.8
BMH-16	< LOD	7.4	2.2	90.5	7.4	< LOD	14.5	4.1	70.7	< LOD	< LOD	< LOD	1.1	56.5
BMH-17	< LOD	8.0	2.1	89.9	8.0	< LOD	14.9	4.9	65.3	3.2	< LOD	< LOD	1.5	54.9
BMH-18	< LOD	7.4	2.1	90.6	6.7	< LOD	14.9	4.5	65.5	4.4	< LOD	0.6	1.4	58.0
BMH-19	0.6	7.4	2.1	90.0	6.7	< LOD	14.6	4.9	63.7	5.5	< LOD	0.7	1.1	55.5

Table S14 - Molar percentual of uronic acid residues of 39 bovine mucosa heparin samples

Sample	G2OH	G2S	I2OH	I2S	G-ANAc,6X	G-ANS,6X	G-ANS,3S,6X	I-ANY	I-ANY,6S	I2S-ANH2,6X	I2S-ANY,3X,6X	GalA	Epox
BMH-1	13.5	1.9	4.7	77.9	7.9	5.6	< LOD	3.1	1.6	0.8	77.1	2.0	< LOD
BMH-2	13.8	1.9	4.5	79.8	8.7	5.0	< LOD	3.3	1.2	1.6	78.3	< LOD	< LOD
BMH-3	13.7	2.1	3.8	80.4	8.0	4.9	0.8	2.9	0.9	1.2	79.2	< LOD	< LOD
BMH-4	12.5	1.8	3.8	81.9	8.7	3.8	< LOD	2.8	1.0	1.3	80.6	< LOD	< LOD
BMH-5	12.4	1.6	3.5	82.5	8.0	4.4	< LOD	2.7	0.9	1.6	80.9	< LOD	< LOD
E1	14.3	2.0	5.2	78.5	8.6	5.7	< LOD	3.2	2.1	0.8	77.7	< LOD	< LOD
F1	13.6	1.8	4.4	80.2	8.2	5.4	< LOD	2.8	1.6	< LOD	80.2	< LOD	< LOD
G1	13.5	2.1	4.9	79.5	8.5	4.9	< LOD	3.1	1.8	< LOD	79.5	< LOD	< LOD
H1	13.3	1.9	5.1	79.8	6.9	5.8	< LOD	3.0	2.1	0.6	79.2	< LOD	< LOD
E2	17.6	1.8	6.1	74.5	10.5	7.0	< LOD	3.7	2.4	1.2	73.4	< LOD	< LOD
F2	17.8	1.8	5.7	74.7	11.3	5.7	0.8	3.7	1.9	1.6	73.1	< LOD	< LOD
G2	17.9	1.9	6.2	74.0	11.7	6.3	< LOD	4.1	2.1	1.3	72.7	< LOD	< LOD
K1	13.8	1.6	4.1	80.6	8.7	5.0	< LOD	2.9	1.2	1.2	79.3	< LOD	< LOD
L1	12.9	2.1	4.4	80.7	7.6	5.2	< LOD	2.9	1.4	1.4	79.3	< LOD	< LOD
M1	13.6	1.7	4.0	80.6	7.2	5.7	0.8	2.5	1.6	1.5	79.1	< LOD	< LOD
N1	12.9	1.7	3.9	81.6	6.9	5.4	0.5	3.0	0.9	1.6	79.9	< LOD	< LOD
O1	12.8	2.0	3.7	81.5	7.2	4.8	0.8	2.7	1.0	1.5	80.1	< LOD	< LOD
P1	12.3	1.6	3.7	82.5	8.0	4.3	< LOD	2.7	1.0	1.9	80.6	< LOD	< LOD
Q1	13.7	1.8	4.1	80.4	9.0	4.7	< LOD	3.0	1.1	1.2	79.2	< LOD	< LOD
R1	12.9	1.8	4.4	80.9	8.2	4.6	< LOD	3.2	1.2	1.5	79.4	< LOD	< LOD
S1	12.3	1.9	3.9	82.0	7.9	4.4	< LOD	2.6	1.3	1.4	80.5	< LOD	< LOD
O2	13.2	2.2	4.7	74.4	8.1	5.1	< LOD	2.9	1.9	1.0	73.3	4.3	1.3
P2	13.2	2.1	4.2	71.9	8.1	5.2	< LOD	2.4	1.7	0.9	71.0	7.2	1.4
Q2	12.2	2.1	4.0	74.2	7.3	4.9	< LOD	2.4	1.7	0.7	73.6	6.4	1.1
R2	12.9	2.6	3.9	66.1	6.9	5.4	0.6	2.5	1.4	0.8	65.3	9.8	4.8
BMH-6	13.7	1.4	4.9	77.8	7.4	6.4	< LOD	2.8	2.1	0.8	77.0	2.2	< LOD
BMH-7	13.7	1.9	5.2	78.4	8.0	4.6	1.1	3.6	1.6	1.0	77.4	0.8	< LOD
BMH-8	13.3	1.7	4.3	79.7	8.0	5.3	< LOD	2.7	1.6	1.4	78.4	1.0	< LOD
BMH-9	14.1	1.8	4.7	79.4	9.0	5.1	< LOD	3.2	1.5	1.6	77.8	< LOD	< LOD
BMH-10	15.5	1.6	4.4	78.5	8.8	5.8	1.0	3.1	1.3	1.1	77.3	< LOD	< LOD
BMH-11	14.1	2.0	4.7	79.2	9.1	5.0	< LOD	3.3	1.4	1.2	77.9	< LOD	< LOD
BMH-12	11.6	1.6	4.8	78.8	6.3	5.3	< LOD	3.0	1.9	1.3	77.5	3.2	< LOD
BMH-13	13.1	1.3	4.8	78.7	8.0	5.1	< LOD	2.7	2.1	1.2	77.5	2.1	< LOD
BMH-14	13.8	1.1	5.1	78.5	7.3	5.7	0.8	3.3	1.8	1.3	77.2	1.6	< LOD
BMH-15	14.3	1.5	5.2	78.1	7.4	5.5	1.5	3.1	2.1	1.4	76.7	0.9	< LOD
BMH-16	12.5	1.1	4.9	81.6	8.1	4.4	< LOD	2.8	2.1	0.9	80.6	< LOD	< LOD
BMH-17	13.2	1.5	4.8	79.5	7.3	5.9	< LOD	3.0	1.8	1.4	78.1	0.9	< LOD
BMH-18	13.1	1.1	5.2	79.3	7.5	4.7	0.9	3.2	1.9	1.4	77.9	1.4	< LOD
BMH-19	13.3	1.2	4.8	78.6	7.8	5.5	< LOD	3.0	1.7	1.5	77.1	2.2	< LOD

Table S15 - Linkage region and sulfation degree of 39 bovine mucosa heparin samples

Sample	LR	oxSer	DSulf
BMH-1	3.0	100.0	2.26
BMH-2	2.8	74.6	2.25
BMH-3	1.8	100.0	2.27
BMH-4	1.6	100.0	2.28
BMH-5	1.8	100.0	2.28
E1	1.7	100.0	2.29
F1	3.3	100.0	2.26
G1	2.4	79.5	2.28
H1	2.8	100.0	2.30
E2	2.4	100.0	2.30
F2	4.1	100.0	2.16
G2	5.7	30.2	2.15
K1	4.1	38.9	2.13
L1	2.1	100.0	2.25
M1	1.0	100.0	2.29
N1	1.0	100.0	2.31
O1	1.3	100.0	2.33
P1	1.1	100.0	2.33
Q1	1.5	100.0	2.30
R1	2.1	100.0	2.26
S1	2.2	100.0	2.28
O2	1.8	100.0	2.31
P2	2.6	100.0	2.30
Q2	4.4	54.8	2.25
R2	3.3	100.0	2.28
BMH-6	4.1	64.1	2.22
BMH-7	4.0	42.0	2.21
BMH-8	2.0	100.0	2.30
BMH-9	1.6	100.0	2.28
BMH-10	2.1	100.0	2.29
BMH-11	1.7	100.0	2.27
BMH-12	2.8	100.0	2.28
BMH-13	2.2	100.0	2.29
BMH-14	3.2	100.0	2.29
BMH-15	3.7	100.0	2.34
BMH-16	1.7	100.0	2.28
BMH-17	3.7	100.0	2.30
BMH-18	3.2	100.0	2.33
BMH-19	2.8	63.2	2.29

Table S16- Molar percentual of glucosamine residues of 7 beef lung heparin samples

Sample	ANH2,6x	ANAc,6x	ANS,3S,6x	ANS,6X	ANAc,6X-G	ANAc,6X-I	ANS,6X-G	ANS,6X-I	ANS,6X-I2S	ANS,6X-GalA	ANS,6X-Epox	ANAc,6XaRed	ANS,6XaRed	% 6S
BLH-1	0.5	1.7	2.9	94.8	1.7	< LOD	5.2	3.7	83.5	1.4	< LOD	< LOD	1.1	90.3
BLH-2	0.5	1.9	2.6	94.9	1.9	< LOD	7.2	4.2	79.3	0.9	< LOD	< LOD	3.2	90.2
BLH-3	0.7	2.9	2.9	93.4	2.9	< LOD	7.5	3.5	80.3	< LOD	< LOD	< LOD	2.2	89.4
BLH-4	0.6	2.2	3.5	93.7	1.7	0.5	7.8	3.9	78.8	0.8	< LOD	< LOD	2.5	88.9
BLH-5	0.6	3.1	2.4	93.9	3.1	< LOD	8.3	4.4	77.5	0.8	< LOD	< LOD	2.8	87.8
BLH-6	0.8	3.5	3.3	92.4	3.5	< LOD	7.7	3.1	79.4	< LOD	< LOD	< LOD	2.2	88.6
BLH-7	0.8	3.2	3.5	92.5	2.7	0.5	7.8	4.5	77.5	0.6	< LOD	< LOD	2.1	88.4

Table S17 - Molar percentual of uronic acid residues of 7 beef lung heparin samples

Sample	G2OH	G2S	I2OH	I2S	G-ANAc,6X	G-ANS,6X	G-ANS,3S,6X	I-ANY	I-ANY,6S	I2S-ANH2,6X	I2S-ANY,3X,6X	GalA	Epox
BLH-1	2.7	< LOD	2.1	95.3	0.5	1.4	0.8	< LOD	2.1	0.8	94.4	< LOD	< LOD
BLH-2	4.6	0.4	2.9	92.1	1.7	2.0	0.8	0.8	2.1	1.4	90.7	< LOD	< LOD
BLH-3	4.4	0.5	2.7	92.4	1.5	2.2	0.7	0.6	2.1	1.1	91.3	< LOD	< LOD
BLH-4	4.5	0.5	2.6	92.4	1.7	2.2	0.6	< LOD	2.6	1.1	91.2	< LOD	< LOD
BLH-5	5.4	0.7	3.5	90.3	2.0	2.6	0.9	1.0	2.6	1.1	89.3	< LOD	< LOD
BLH-6	4.3	< LOD	3.2	92.5	1.6	2.7	< LOD	0.8	2.4	1.2	91.3	< LOD	< LOD
BLH-7	5.4	0.6	3.3	90.8	1.8	2.6	1.0	0.9	2.4	1.9	88.9	< LOD	< LOD

Table S18 - Linkage region and sulfation degree of 7 Beef lung heparin samples

Sample	LR	%ox Ser	DSulf
BLH-1	< LOD	NA	2.86
BLH-2	1.3	100.0	2.83
BLH-3	1.3	100.0	2.82
BLH-4	1.1	10.00	2.82
BLH-5	1.0	100.0	2.78
BLH-6	1.5	64.0	2.80
BLH-7	1.5	72.1	2.79

Table S19 - Molar percentual of glucosamine residues of 6 ovine mucosa heparin samples

Sample	ANH2,6x	ANAc,6x	ANS,3S,6x	ANS,6X	ANAc,6X-G	ANAc,6X-I	ANS,6X-G	ANS,6X-I	ANS,6X-I2S	ANS,6X-GalA	ANS,6X-Epox	ANAc,6XaRed	ANS,6XaRed	% 6S
OMH-1	< LOD	5.2	7.3	87.5	4.5	< LOD	12.9	7.8	58.4	6.5	< LOD	0.7	2.0	89.6
OMH-2	< LOD	4.9	5.4	89.7	4.1	< LOD	8.7	5.5	72.9	0.7	< LOD	0.8	2.0	86.4
OMH-3	0.9	5.1	5.7	88.3	4.2	< LOD	10.1	5.0	70.4	1.4	< LOD	0.9	1.4	86.7
OMH-4	< LOD	4.5	5.5	90.0	3.7	< LOD	9.9	5.5	71.0	1.6	< LOD	0.8	2.0	87.9
OMH-5	1.1	5.8	6.6	86.5	4.7	< LOD	11.0	6.1	68.1	< LOD	< LOD	1.1	1.4	86.9
OMH-6	0.9	7.1	7.2	84.8	5.8	< LOD	11.2	5.6	65.5	0.7	< LOD	1.3	1.8	86.0

Table S20 - Molar percentual of uronic acid of 6 ovine mucosa heparin samples

Sample	G2OH	G2S	I2OH	I2S	G-ANAc,6X	G-ANS,6X	G-ANS,3S,6X	I-ANY	I-ANY,6S	I2S-ANH2,6X	I2S-ANY,3X,6X	GalA	Epox
OMH-1	11.98	< LOD	6.83	71.41	2.31	6.84	2.83	0.7	6.13	< LOD	71.41	9.78	< LOD
OMH-2	7.8	< LOD	5.1	87.1	1.4	5.1	1.3	0.6	4.6	0.8	86.4	< LOD	< LOD
OMH-3	6.9	< LOD	5.2	87.9	1.6	4.4	0.9	0.9	4.3	1.2	86.7	< LOD	< LOD
OMH-4	7.3	< LOD	6.1	86.6	1.5	4.8	1.0	0.9	5.2	< LOD	86.6	< LOD	< LOD
OMH-5	7.8	< LOD	5.9	86.4	2.3	4.4	1.0	0.8	5.1	1.5	84.9	< LOD	< LOD
OMH-6	8.2	< LOD	6.0	85.9	2.6	4.7	0.9	0.7	5.2	1.2	84.7	< LOD	< LOD

Table S21 - Linkage region and sulfation degree of 6 ovine mucosa heparin samples

Sample	LR	%ox Ser	DSulf
OMH-1	1.4	100.0	2.63
OMH-2	2.5	26.4	2.74
OMH-3	2.7	0.0	2.74
OMH-4	2.6	0.0	2.76
OMH-5	3.8	27.9	2.73
OMH-6	3.4	42.5	2.71