FIG. 1A


pNadA
TAACAGATATTAATGCCGAACTACCTAACTGCAAGAATTAAATAAATAAATAAATAAATAAATAAATAAATAAAT
-35
-10
+1
AAATTGCGACAATGTATTGTATATATGCCTCCTTTCATATATACTTTAATATGTAAACAAACTT
GGTGGGGATAAAATACTTACAAAAGATTTCCGCCCCATTTTTTATCCACTCACAAAGGTAATG
pPorA
AATAAGCTATTGTTTTATATCAAAATATAATCATTTTTAAAATAAAGGTTGCGGCATTTATCAGATATTTG
TTCTGAAAAATGGTTTTTTGCCGGGGGGGGGGGTATAATTGAAGACGTATCGGGTGTTTGCCCGA
TGTTTTTAGGTTTTTATCAAATTTACAAAAGGAAGCCCATATG

FIG. 1B

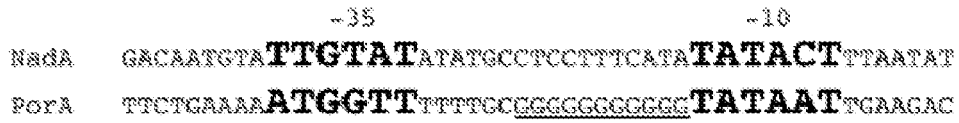
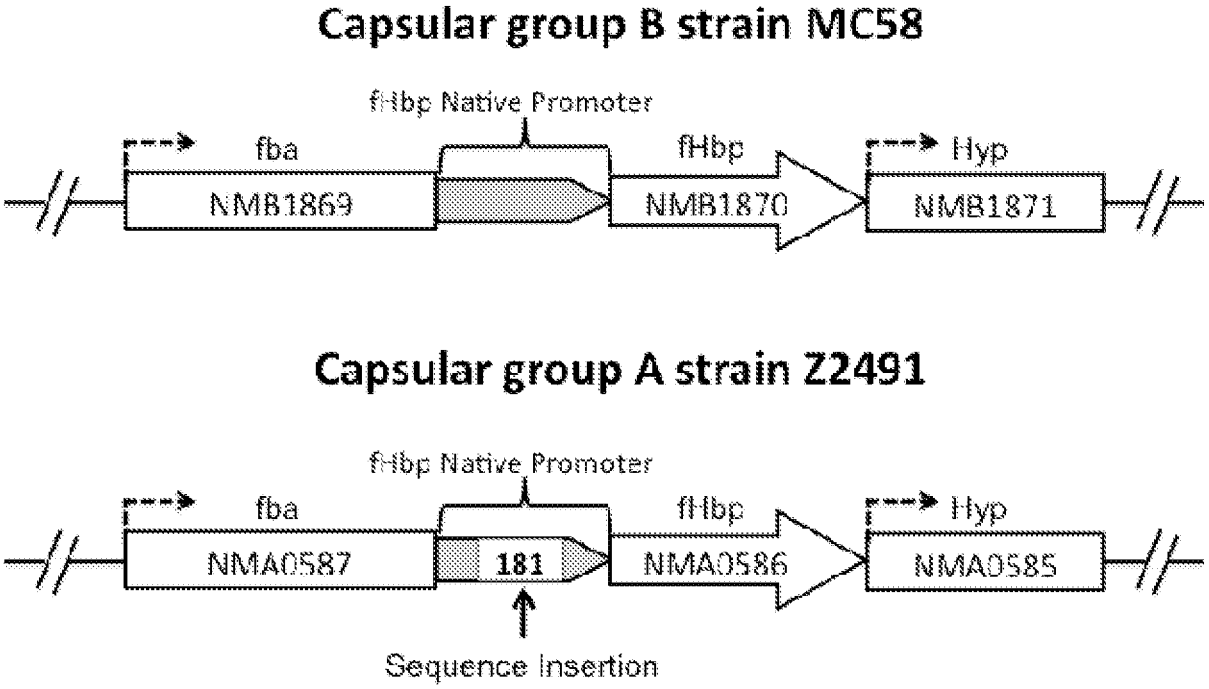

-35
-10
NadA GACAATGTATTGTATATATGCCTCCTTTCATATATACTTTAATAT
PorA TTCTGAAAAATGGTTTTTTGCCGGGGGGGGGGGTATAATTGAAGAC

FIG. 2



fba= fructose-1,6-bisphosphate aldolase
fHbp= factor H binding protein
Hyp = hypothetical protein

FIG. 3

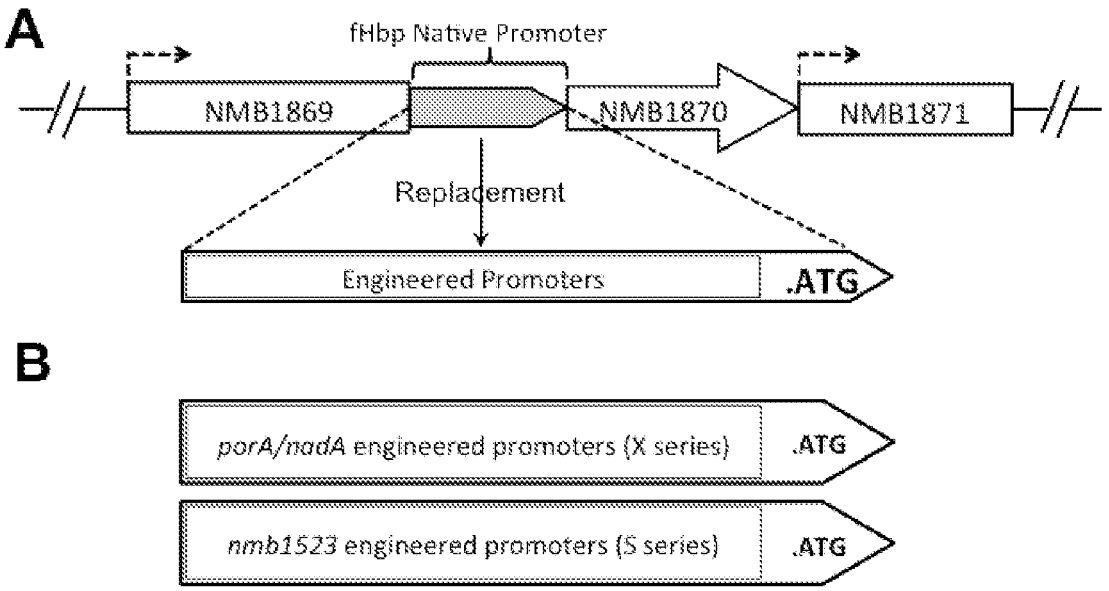
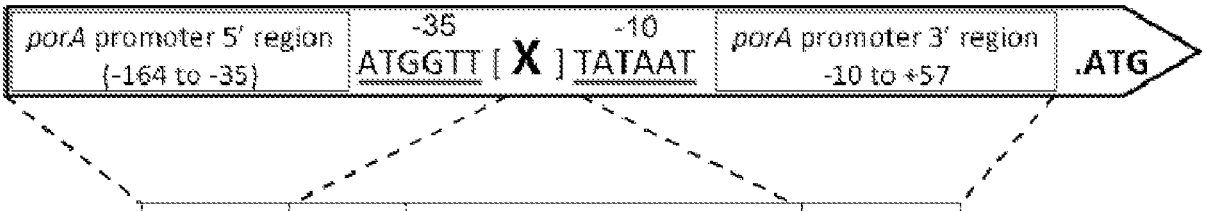

A
fHbp Native Promoter
NMB1869
NMB1870
NMB1871
Replacement
Engineered Promoters
.ATG
B
porA/nadA engineered promoters (X series)
.ATG
nmb1523 engineered promoters (S series)
.ATG

FIG. 4

porA/nadA based family (X series)



	Name	Modification & Sequence	
porA promoter 5′ region	X0	None (*porA* native) TTTTGCGGGGGGGGGG	*porA* promoter 3′ region
	X1	*nadA* promoter spacer **ATATGCCTCCTTTCATA**	
	X5	*porA*/***nadA*** hybrid spacer TTTTGCGGG**CTTTCATA**	
	X6	*porA*/***nadA*** hybrid spacer TTTTGCGGG**CTTTCA**GGG	
	X7	*porA*/***nadA*** hybrid spacer TTTTGCGGG**CTTTCA**G	

FIG. 5

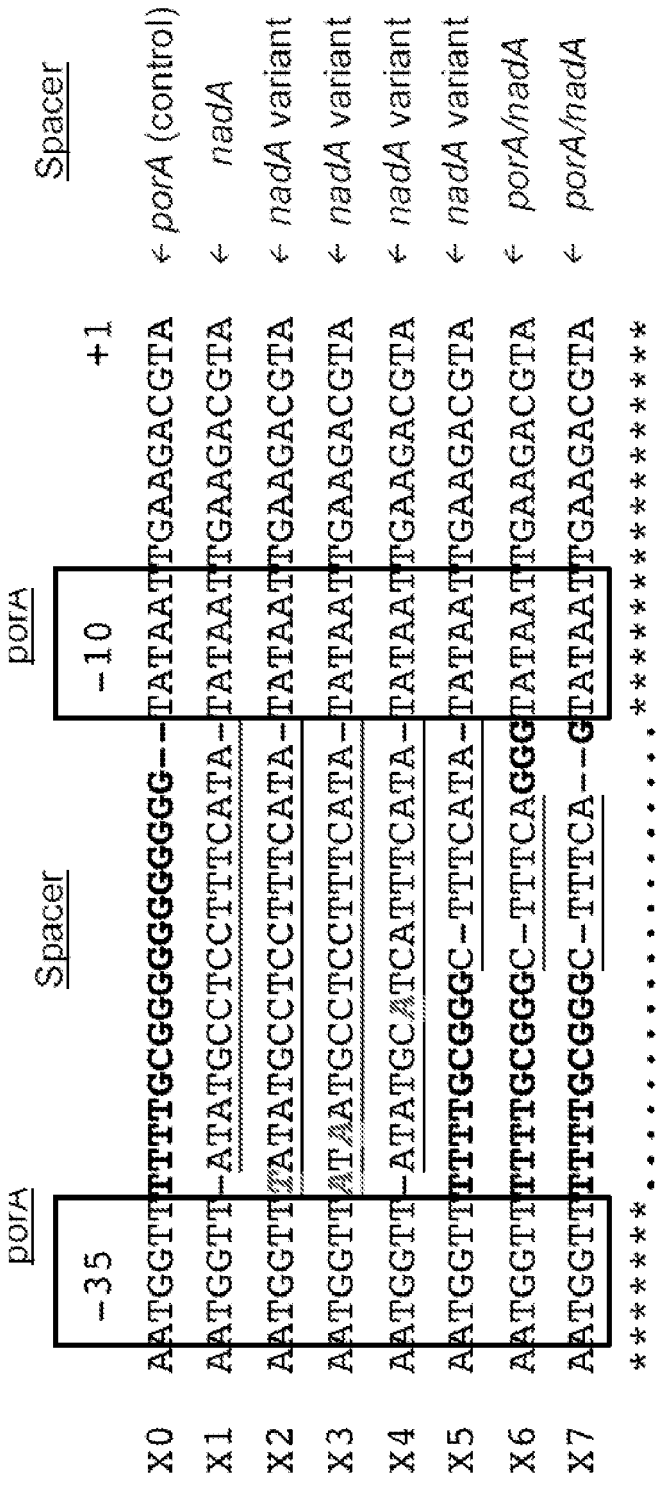

porA
Spacer
-35
porA
Spacer
-10
+1
Spacer
X0 AATGGTTTTTTGCGGGGGGGGGGG--TATAATTGAAGACGTA ← porA (control)
X1 AATGGTT-ATATGCCTCCTTTCATA-TATAATTGAAGACGTA ← nadA
X2 AATGGTTTATATGCCTCCTTTCATA-TATAATTGAAGACGTA ← nadA variant
X3 AATGGTTTTATGCCTCCTTTCATA-TATAATTGAAGACGTA ← nadA variant
X4 AATGGTT-ATATGCATTTTCATA-TATAATTGAAGACGTA ← nadA variant
X5 AATGGTTTTTTGCGGGC-TTTCATA-TATAATTGAAGACGTA ← nadA variant
X6 AATGGTTTTTTGCGGGC-TTTCAGGGTATAATTGAAGACGTA ← porA/nadA
X7 AATGGTTTTTTGCGGGC-TTTCA--GTATAATTGAAGACGTA ← porA/nadA

FIG. 6

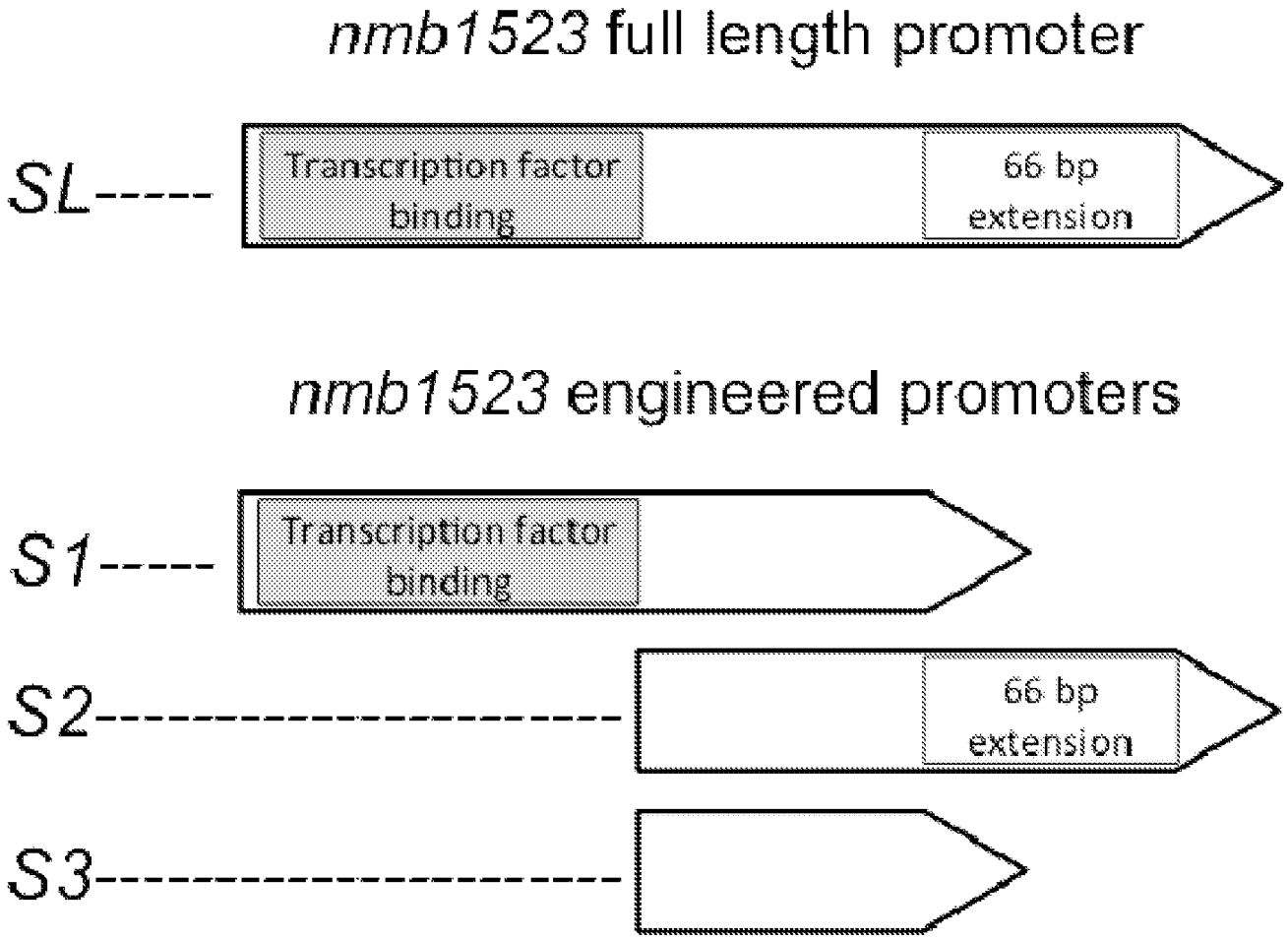

nmb1523 full length promoter
SL-----
Transcription factor binding
66 bp extension
nmb1523 engineered promoters
S1-----
Transcription factor binding
S2----------
66 bp extension
S3----------

FIG. 7

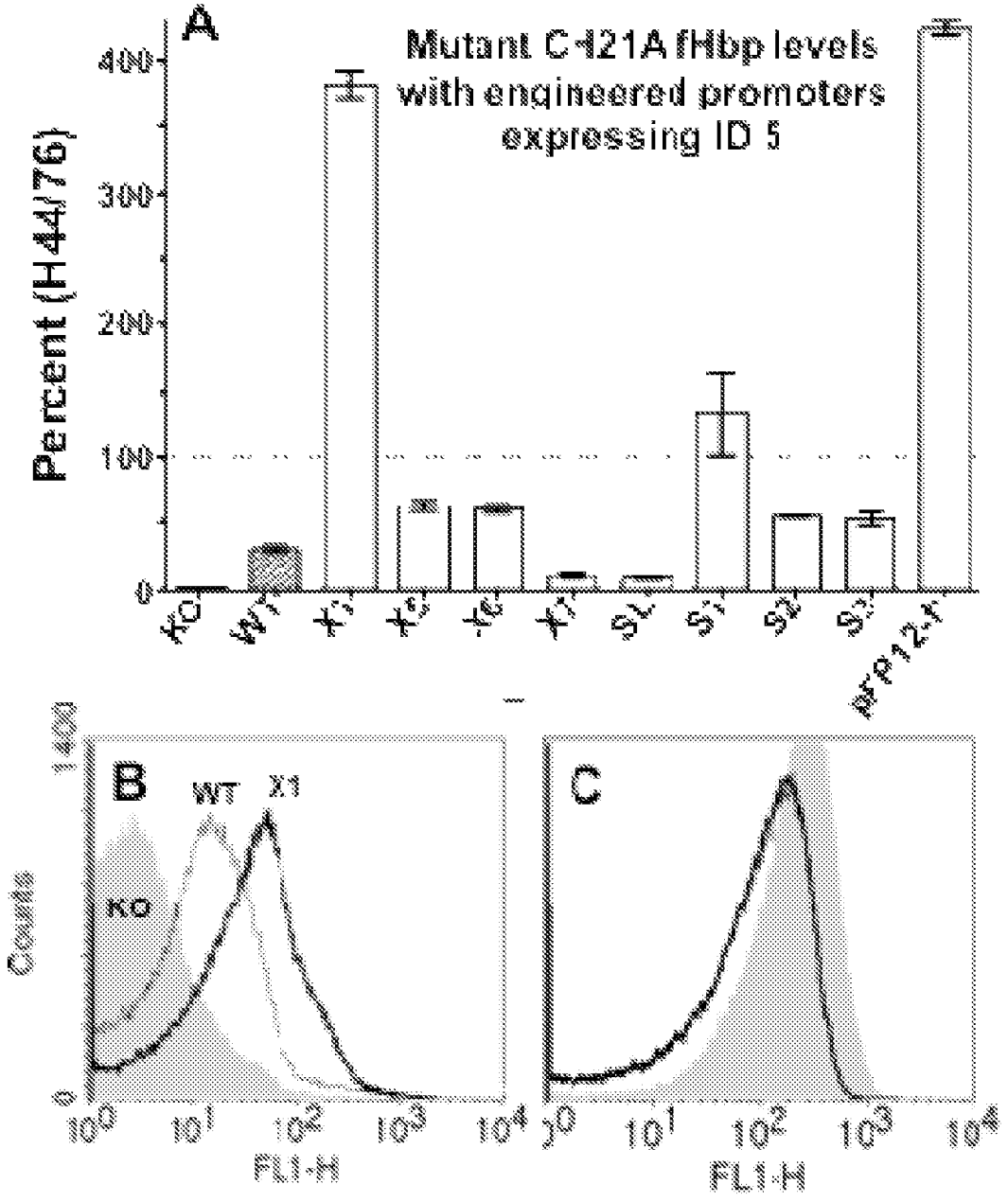

A
Mutant C-121A fHbp levels
with engineered promoters
expressing ID 5
Percent (H44/76)
400
300
200
100
0
KO
WT
X1
X2
X3
X4
X5
S1
S2
S3
S4
ΔFP12-K
B
WT
X1
KO
Counts
140
0
10^0
10^1
10^2
10^3
10^4
FL1-H
C
10^0
10^1
10^2
10^3
10^4
FL1-H

FIG. 8

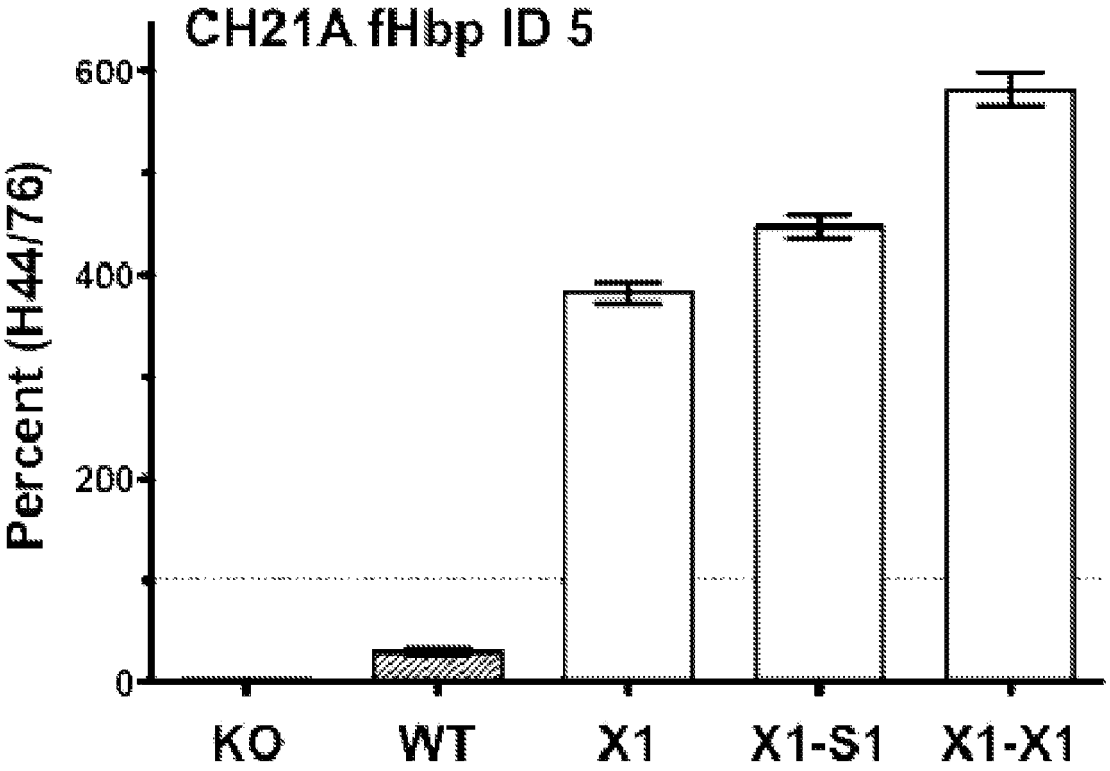


FIG. 9

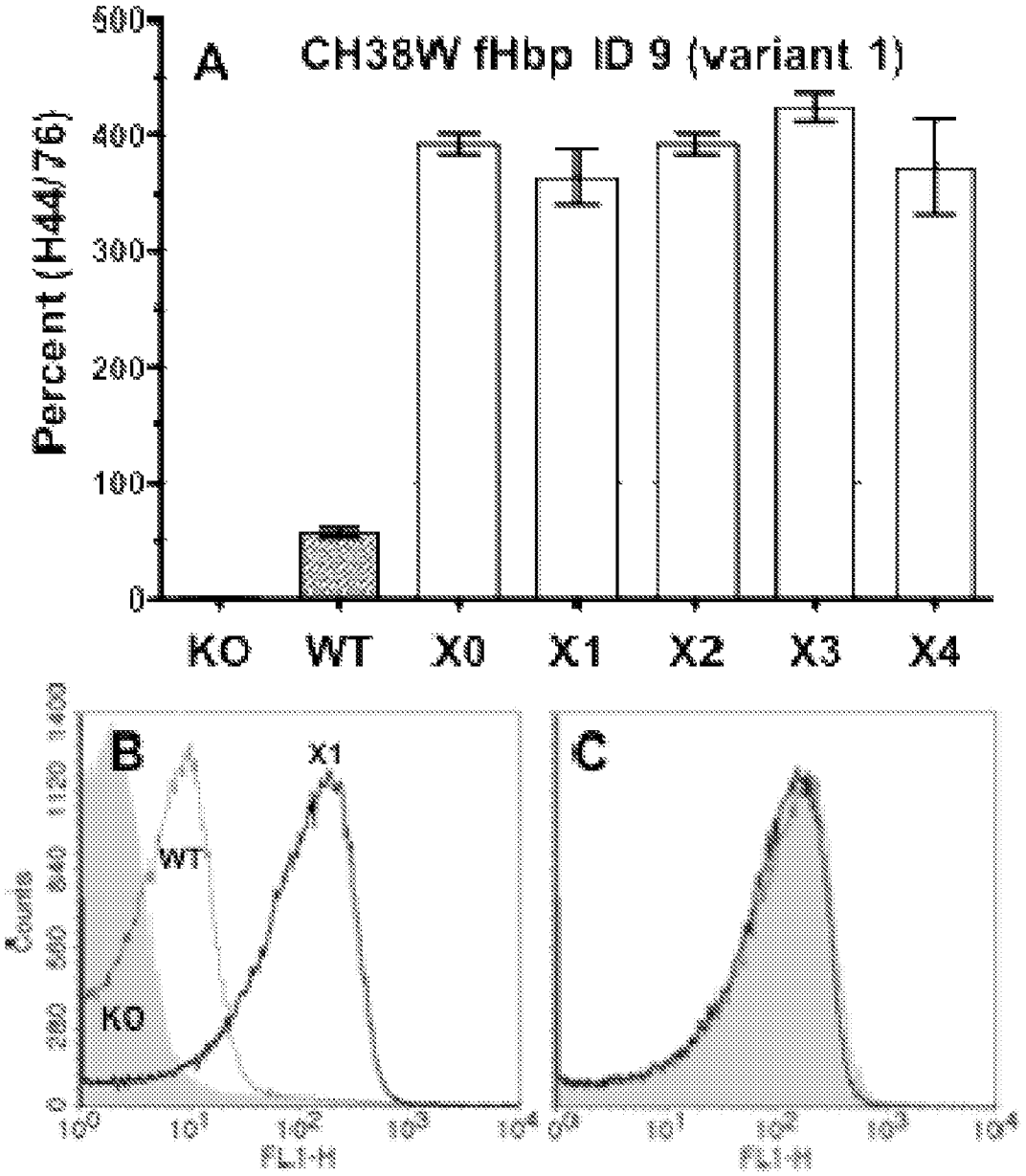

A
CH38W fHbp ID 9 (variant 1)
Percent (H44/76)
500
400
300
200
100
0
KO
WT
X0
X1
X2
X3
X4
B
X1
WT
KO
Counts
FL1-H
C
FL1-H

FIG. 10

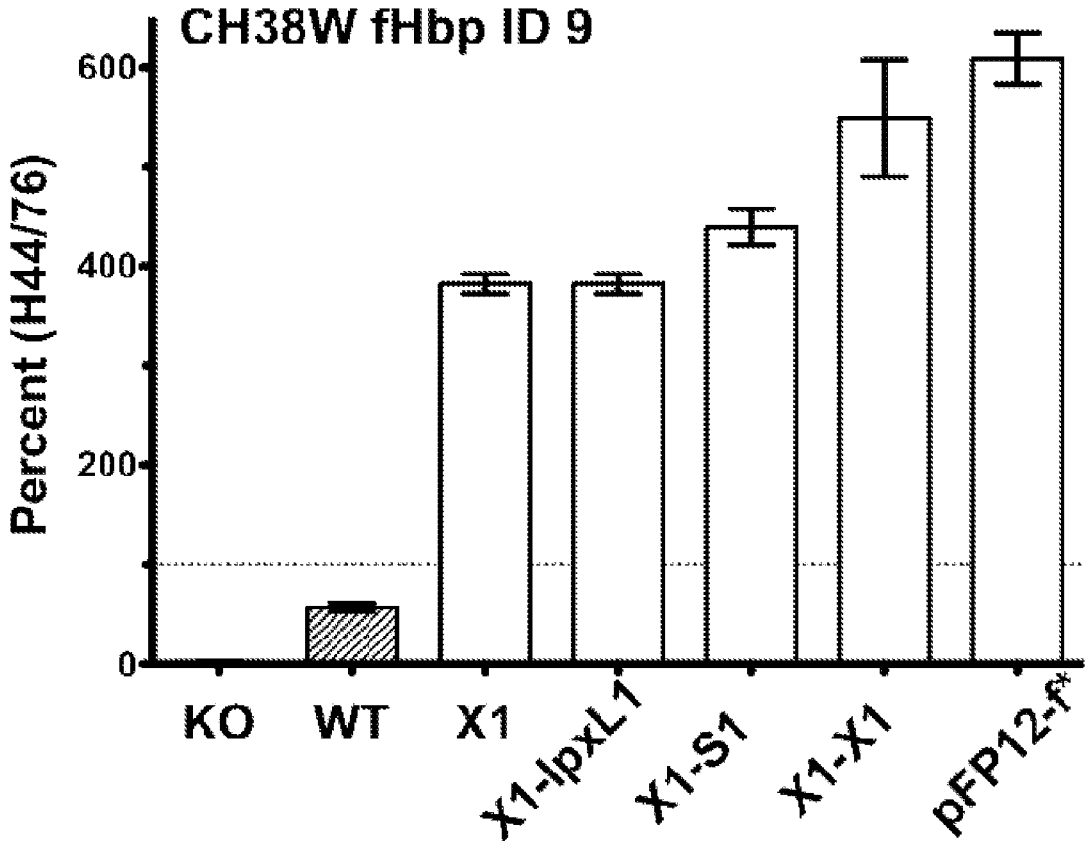

CH38W fHbp ID 9
Percent (H44/76)
600
400
200
0
KO
WT
X1
X1-lpxL1
X1-S1
X1-X1
pFP12-f*

FIG. 11

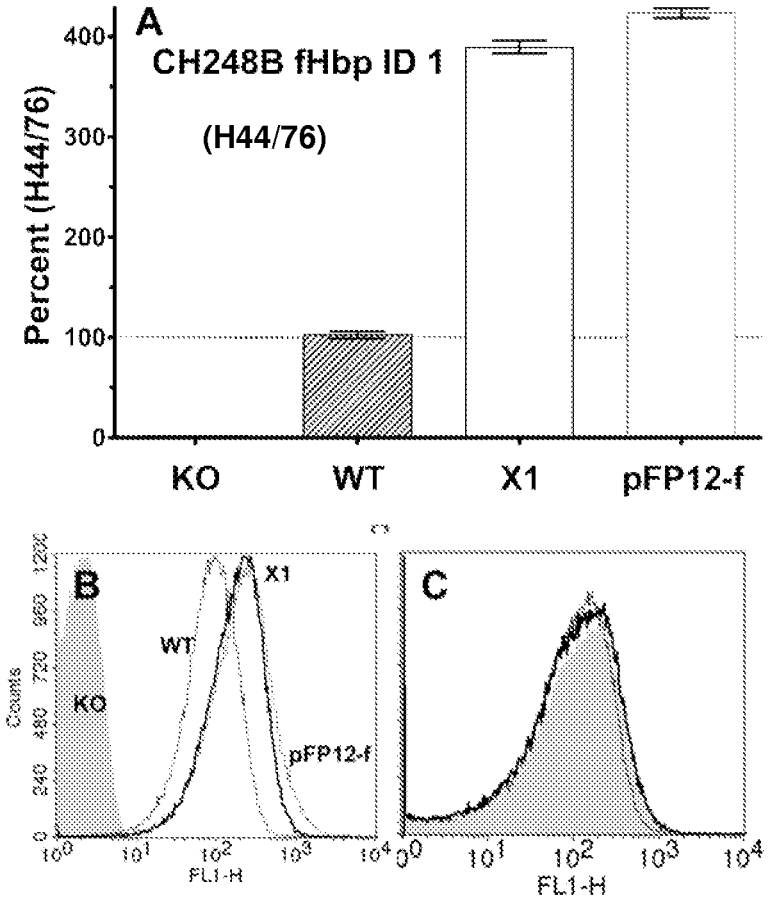

A
CH248B fHbp ID 1
(H44/76)
Percent (H44/76)
400
300
200
100
0
KO
WT
X1
pFP12-f
B
C
X1
WT
KO
pFP12-f
Counts
FL1-H
FL1-H

FIG. 12

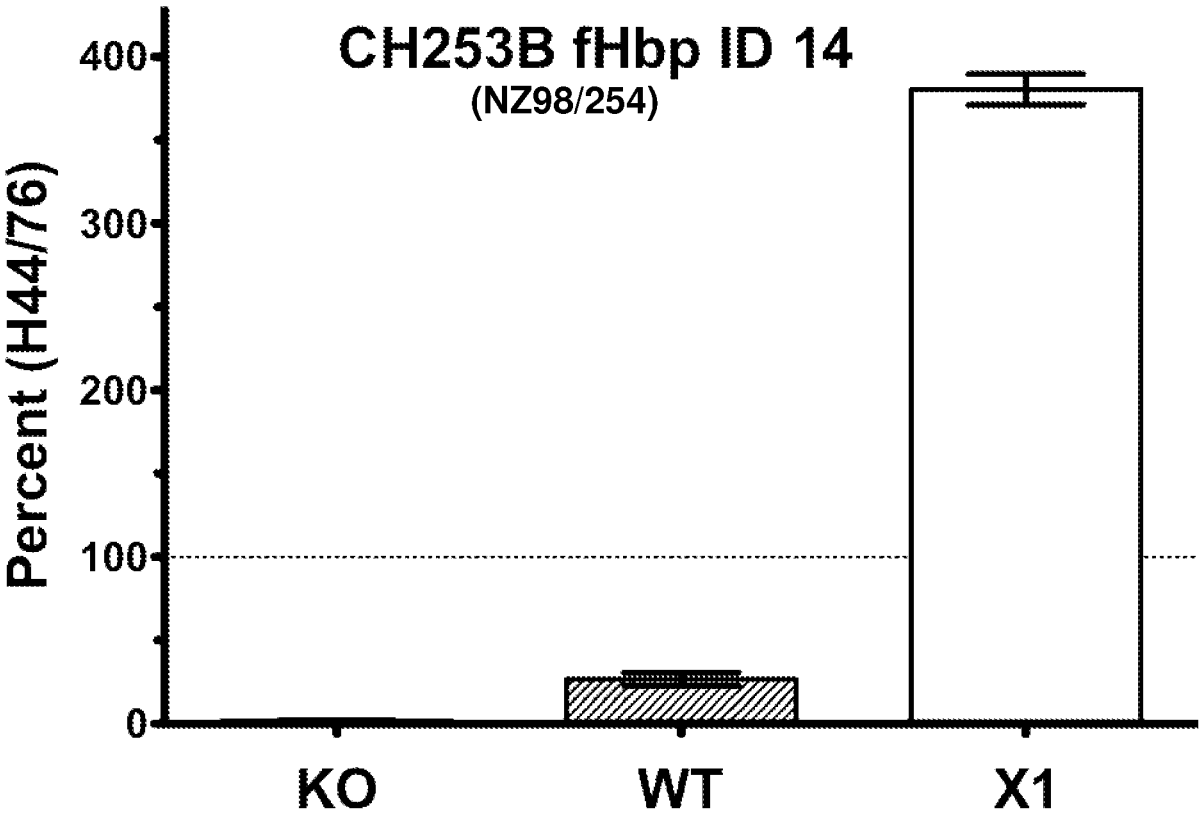

CH253B fHbp ID 14
(NZ98/254)
Percent (H44/76)
400
300
200
100
0
KO
WT
X1

FIG. 13

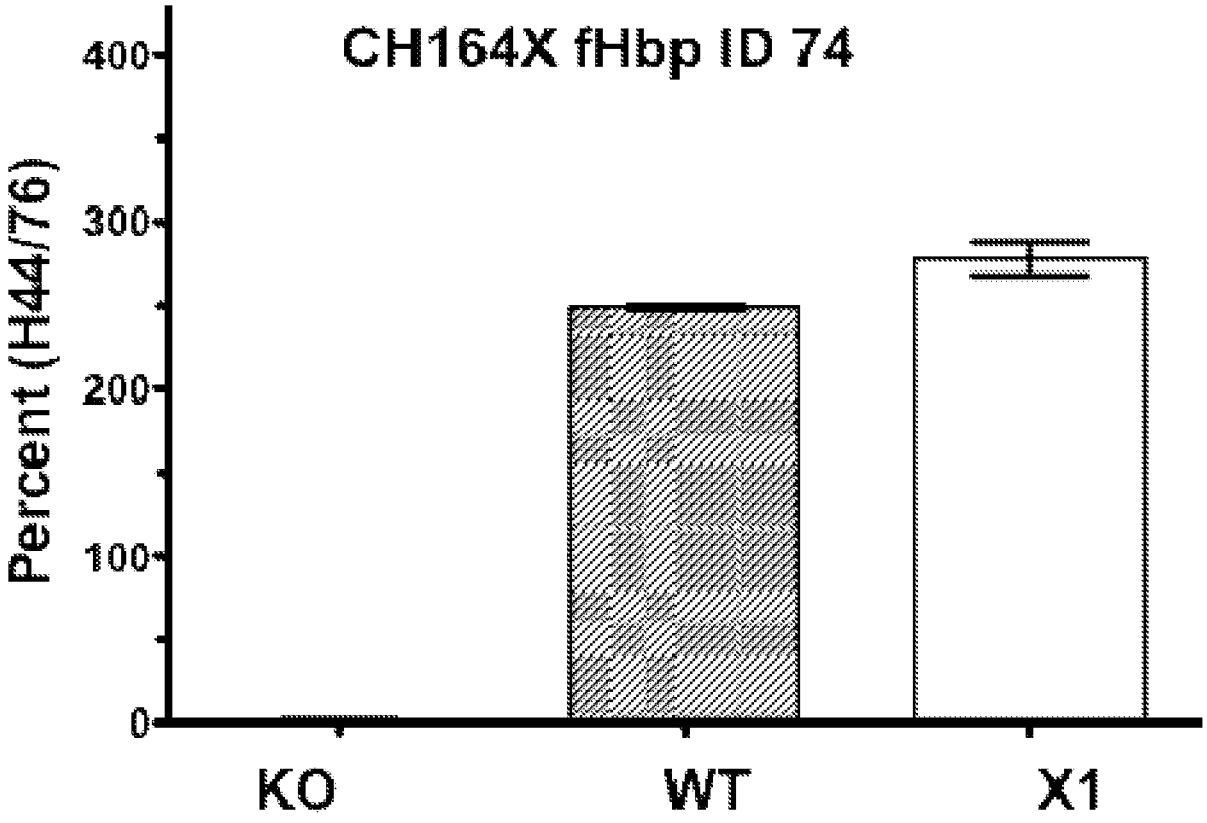


FIG. 14

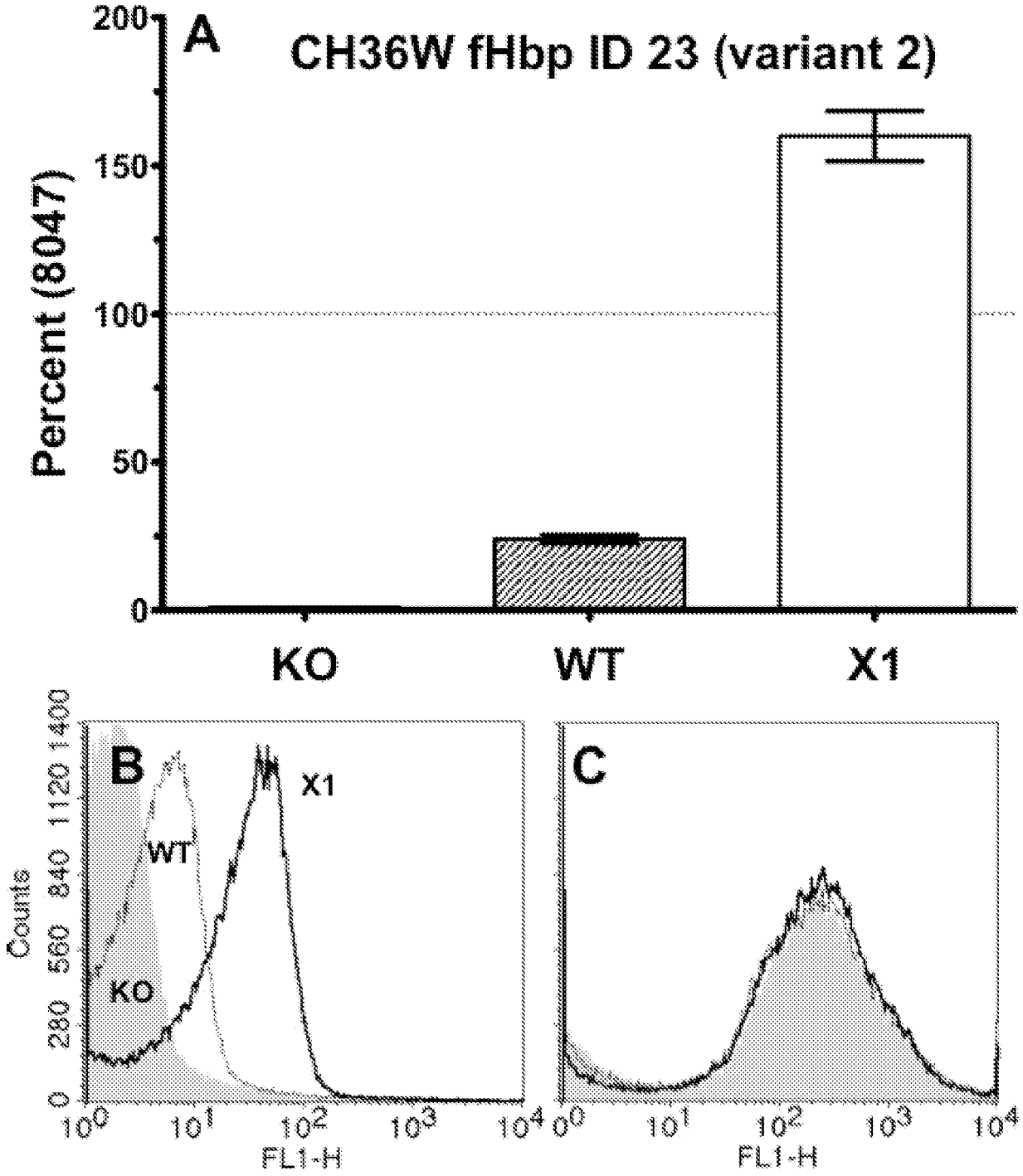

A
CH36W fHbp ID 23 (variant 2)
Percent (8047)
200
150
100
50
0
KO
WT
X1
B
WT
X1
KO
Counts
0
280
560
840
1120
1400
10^0
10^1
10^2
10^3
10^4
FL1-H
C
10^0
10^1
10^2
10^3
10^4
FL1-H

FIG. 15

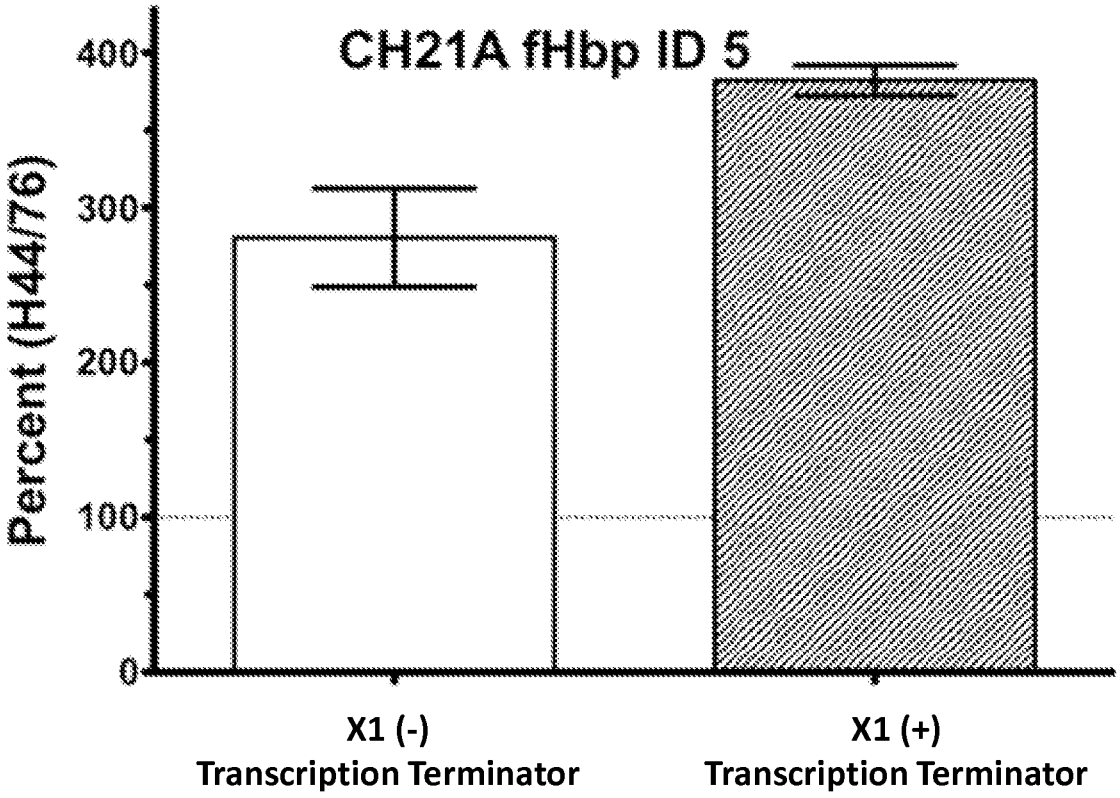

CH21A fHbp ID 5
Percent (H44/76)
400
300
200
100
0
X1 (-)
Transcription Terminator
X1 (+)
Transcription Terminator

FIG. 16

FAM18

Codon	Mean	SD	Codon	Mean	SD	Codon	Mean	SD	Codon	Mean	SD
GCT (A)	9.2	10	CAT (H)	9.1	7.7	CCT (P)	7.5	7	AGT (S)	4.8	5.6
GCC (A)*	41	23	CAC (H)*	13.1	9.7	CCC (P)	14.3	10	AGC (S)*	15.9	9.6
GCG (A)	28.8	19	ATT (I)	22.4	14	CCG (P)*	17.9	11	ACT (T)	5.9	6.9
GCA (A)	20.4	12	ATC (I)*	30.4	15	CCA (P)	2.4	4.1	ACC (T)*	25.1	14
TGT (C)	3.3	4.6	ATA (I)	6	8.5	CAG (Q)	16.9	11	ACG (T)	13.1	9.1
TGC (C)*	8	7.3	AAG (K)	11.2	10	CAA (Q)*	22	13	ACA (T)	6.6	7
GAT (D)	22.9	15	AAA (K)*	46	20	CGT (R)	11.5	11	GTT (V)	16.9	11
GAC (D)*	29.1	15	TTG (L)	31.1	17	CGC (R)*	26.9	16	GTC (V)*	23.5	13
GAG (E)	12.8	10	TTA (L)	7.9	11	CGG (R)	6.8	7.4	GTG (V)	17.7	13
GAA (E)*	49.2	21	CTT (L)	10.3	7.6	CGA (R)	2.6	3.9	GTA (V)	10.2	8.5
TTT (F)*	21.5	15	CTC (L)	13.3	12	AGG (R)	3.9	5.5	TGG (W)*	12.2	10
TTC (F)	20.5	12	CTG (L)*	35	19	AGA (R)	2.8	5	TAT (Y)	14.8	12
GGT (G)	16.5	13	CTA (L)	2	3.8	TCT (S)	6.3	7.4	TAC (Y)*	15.2	10
GGC (G)*	42.4	20	ATG (M)*	25.1	12	TCC (S)	13.5	8.5	TGA (.)	1.6	2.4
GGG (G)	7.7	7.2	AAT (N)	15	14	TCG (S)	9.6	7.8	TAG (.)	0.4	1.5
GGA (G)	8.9	7.8	AAC (N)*	24.4	13	TCA (S)	4.3	5.7	TAA (.)*	2.1	2.6

FIG. 17

Z2491

Codon	Mean	SD	Codon	Mean	SD	Codon	Mean	SD	Codon	Mean	SD
GCT (A)	9.3	11	CAT (H)	9	7.6	CCT (P)	7.3	7.1	AGT (S)	4.7	5.7
GCC (A)*	41.7	23	CAC (H)*	13.1	9.8	CCC (P)	14.3	10	AGC (S)*	16.1	9.8
GCG (A)	29.6	19	ATT (I)	22.2	14	CCG (P)*	17.8	11	ACT (T)	6	6.8
GCA (A)	20.2	12	ATC (I)*	30.5	15	CCA (P)	2.3	4.2	ACC (T)*	25.2	14
TGT (C)	3.2	4.5	ATA (I)	5.8	8.1	CAG (Q)	17	12	ACG (T)	13.3	9.3
TGC (C)*	8	7.6	AAG (K)	11.3	10	CAA (Q)*	21.9	13	ACA (T)	6.4	7.2
GAT (D)	22.6	14	AAA (K)*	45.7	20	CGT (R)	11.4	11	GTT (V)	16.6	11
GAC (D)*	29.2	15	TTG (L)	31.2	17	CGC (R)*	27.3	16	GTC (V)*	23.6	13
GAG (E)	13	10	TTA (L)	7.7	11	CGG (R)	6.7	7.5	GTG (V)	18.1	13
GAA (E)*	48.9	21	CTT (L)	10	7.5	CGA (R)	2.5	3.8	GTA (V)	10.2	8.5
TTT (F)*	21.7	16	CTC (L)	13.6	12	AGG (R)	3.7	5.6	TGG (W)*	12.2	10
TTC (F)	20.3	12	CTG (L)*	35.6	19	AGA (R)	2.8	5.1	TAT (Y)	14.4	12
GGT (G)	16.3	13	CTA (L)	2.1	3.9	TCT (S)	6.2	7.5	TAC (Y)*	15.2	9.9
GGC (G)*	42.9	20	ATG (M)*	25.1	12	TCC (S)	13.3	8.7	TGA (.)	1.5	2.4
GGG (G)	7.6	7.3	AAT (N)	14.7	14	TCG (S)	9.7	7.8	TAG (.)	0.5	1.5
GGA (G)	8.7	7.5	AAC (N)*	24.5	13	TCA (S)	4.1	5.5	TAA (.)*	2.1	2.6

FIG. 18

```
Optimized      1 ATGACCCGCTCCAAAACCGCTAAATCTGGACCACCTTTTTCTGCTTGTCCCTGACCGCCGCA
Original       1 ATGACTAGGAGCAAACCTGTGAACCGAACTACCTTTTTCTGCCTTTCTCTGACCGCCGCC

Optimized     61 CTGATCTTTGACCGCCTGCAGTCCCTCCGCCGGCGTCTCCAGCGCTGGCGCCGCGTGCCAGCA
Original      61 CTGATTCTGACCGCCTGCAGTAGCGGAGGCGGCGGAAGCGGAGGCGGCGGTGTCGCCGCC

Optimized    121 GAAATCGGTGCAAGCTTGCCGAAGCACTGACCGCACCGTTGGATCAGAAAGACAAAGCC
Original     121 GACATCGGTGCGGGGCTTGCTGATGCACTAACCGCACCGCTCGACCATAAAGACAAAGGT

Optimized    181 CTGCAATCTTGACGCTGGATCAGAACGTCTTAAAAACGAAAAATTGAAACTGGCAACC
Original     181 TTGCAGTCTTTGACGCTGGATCAGTCCGTCAGCAAAAACGAGAAACTGAAGCTGGCGGCA

Optimized    241 CAAGGGGCGGAAAAAACCTATGGTAACGGCGACAGCCTGAATACGGGCAAATTGAAAAAC
Original     241 CAAGGTGCGGAAAAAACTTATGGAAACGGCGACAGCCTCAATACGGGCAAATTGAAGAAC

Optimized    301 GATAAAGTCTCCCGCTTTGACTTCATCCGCCAAATTGAACTTGATGCCCAGTTCATTACC
Original     301 GACAAGGTCAGCCGCTTCGACTTTATCCGTCAAATCGAAGTGGACGGGCAGCTCATTACC

Optimized    361 CTGGAAAGCGGCGAATTTCAAGTGTACAAACAAAGCCATTCCGCCTTAACCGCCCTTCAG
Original     361 TTGGAGAGCGGAGAGTTCCAAGTGTACAAACAAAGCCATTCCGCCTTAACCGCCCTTCAG

Optimized    421 ACCGAGCAAGTACAAGATTCGGAAGACAGCGGCAAAATGGTAGCCAAACGCCAGTTTCGC
Original     421 ACTGAGCAAGTACAAGACTCGGAGGATTCCGGGAAGATGGTTGCGAAACGCCAGTTCAGA

Optimized    481 ATCGGTGATATTGCGGGCGAACATACCTCCTTTGACAAATTCCCAAAGGTGGCTCCGCG
Original     481 ATCGGCGACATAGCGGGCGAACATACGTCTTTTGACAAGCTTCCCAAAGGCGGCAGTGCG

Optimized    541 ACCTATCGCCCTACGGCATTTCCTCCGATCCCCGCTGCAAACTGACCTACACGATC
Original     541 ACATATCGCGGGACGGCGTTCGGTTCAGACGATGCTGGCGGAAAACTGACCTATACTATA

Optimized    601 GACTTCGCCGTCAAACAGGGCACGGCAAAATCGAACATTTGAAAATCCCCGAACTCAAT
Original     601 GATTTCGCCGTCAAACAGGGACACGGCAAAATCGAACATTTGAAATCGCCCGAACTCAAT

Optimized    661 GTAGATTTTGAGGCAGCCTATATCAAACCGGACAAAAAACGCCATGCCGTCATTCAGC
Original     661 GTCGACCTGGCCGCCGCCTATATCAAGCCGGATAAAAAACGCCATGCCGTCATCAGCGGT

Optimized    721 TCGGTTCTGTACAATCAGGATGAAAAAGGTAGCTACTCCTTGGGCATCTTCGGTGGCCAA
Original     721 TCCGTCCTTTACAACCAAGACGAGAAAGGCAGTTACTCCCTCGGCATCTTTGGCGGGCAA

Optimized    781 GCACAGGAAGTTGCCGGCAGCGCGGAAGTTGAAACCGCCAACGGTATCCATCACATCGGC
Original     781 GCCCAGGAAGTTGCCGGCAGCGCGGAAGTGGAAACCGCAAACGGCATACACCATATCGGT

Optimized    841 TTGGCACAAAACAGTAA
Original     841 CTTGCCGCCAAGCAGTAA
```

FIG. 19

fHbp ID 23

ATGACCGGCTCCAAACCCGTGAACCGCACCGCATTCTGCTGCTTTTCGTTGAC
CGCCGCACTGATTCTGACCGCCTGCTCGTCGGGCGGCGGTGGCGTGGCAGCA
GATATCGGTGCAGGCTTGGCGGACGCACTGACCGCACCGTTGGATCATAAAGA
CAAAGGCCTGCAATCCTTGACGCTGGATCAGTCGGTACGCAAAAACGAAAAAT
TGAAACTGGCAGCCCAAGGCGCCGAAAAAACCTATGGTAACGGCGACTCCCTG
AATACGGGCAAATTGAAAAATGATAAAGTGTCGCGCTTTGACTTCATCCGCCAA
ATTGAAGTAGATGGCCAGTTGATCACCCTGGAATCGGGCGAATTTCAAATTTAC
AAACAGGACCACAGCGCAGTCGTTGCCCTGCAAATCGAAAAAATCAACAACCC
GGATAAAATCGACAGCTTGATTAACCAGCGCTCGTTTCTGGTTAGCGGCTTGG
GTGGCGAACACACCGCCTTCAATCAACTGCCGAGCGGTAAAGCCGAATATCAT
GGCAAAGCGTTTAGCTCCGATGACCCCAACGGCCGCCTGCACTATTCCATCGA
TTTCACCAAAAAACAAGGTTACGGCCGCATTGAACATTTGAAAACGCCCGAACA
GAATGTCGAACTGGCCAGCGCGGAATTGAAAGCAGATGAAAAATCCCATGCGG
TTATCTTGGGCGACACCCGCTATGGTGGCGAAGAAAAAGGCACGTACCACTTG
GCACTGTTCGGTGACCGCGCACAGGAAATTGCAGGCTCGGCGACGGTAAAAAT
CCGCGAAAAAGTTCACGAAATCGGTATTGCAGGTAAACAGTAA

FIG. 20

fHbp ID 4

ATGACCCGCTCGAAACCCGTGAACCGCACCGCATTCTGCTGCTTGTCGTTGAC
CGCCGCCCTGATTTTGACCGCCTGCTCGTCCGGCGGCGGTGGCGTGGCAGCA
GATATCGGTGCAGGCTTGGCAGACGCCCTGACCGCACCGTTGGATCACAAAGA
CAAATCGCTGCAAAGCTTGACGCTGGATCAGAGCGTATCCAAAAACGAAAAATT
GAAACTGGCAGCCCAAGGCGCCGAAAAAACCTATGGTAACGGCGACAGCCTG
AATACGGGCAAATTGAAAAATGATAAAGTCTCCCGCTTTGACTTCATCCGCCAA
ATTGAAGTTGATGGCCAGTTGATTACCCTGGAAAGCGGCGAATTTCAAGTCTAC
AAACAGTCGCACAGCGCGTTGACCGCACTGCAAACGGAACAAGTGCAGGACTC
CGAACATTCGGGCAAAATGGTAGCGAAACGCCAGTTTCGCATCGGTGATATTG
CCGGCGAACACACCAGCTTCGACAAATTGCCCGAAGGTGGCCGCGCAACCTAT
CGCGGTACGGCATTTGGCAGCGATGACGCGTCCGGCAAACTGACCTACACGA
TCGATTTCGCGGCAAAACAAGGTCACGGCAAAATTGAACATTTGAAATCGCCG
GAACTGAACGTGGACTTGGCCGCGTCCGATATCAAACCCGACAAAAAACGCCA
TGCGGTCATTTCCGGCTCGGTTCTGTATAATCAGGCCGAAAAAGGTAGCTACTC
CTTGGGCATCTTCGGTGGCCAAGCCCAGGAAGTTGCGGGCTCGGCAGAAGTA
GAAACCGCAAATGGTATCCGCCACATCGGCTTGGCAGCAAAACAATAA

FIG. 21

fHbp ID 28

GGCGTAGCAGCTGACATCGGTACCGGCCTGGCGGACGCTCTGACCGCCCCGT
TGGACCATAAAGACAAAGGCCTGAAAAGCCTGACCTTGGAAGACAGCATTCCG
CAAAACGGTACACTCACGCTGAGCGCTCAAGGCGCCGAAAAAACCTTCAAAGC
GGGCGACAAAGATAACTCTCTGAACACCGGCAAACTGAAAAATGACAAAATTTC
TCGCTTCGACTTCGTACAAAAAATCGAAGTCGACGGTCAAACAATCACATTGGC
AAGCGGCGAATTCCAAATTTATAAACAAAACCACTCAGCCGTTGTCGCCCTGCA
AATTGAGAAAATTAACAACCCTGACAAAACGGACTCCCTGATCAACCAACGTTC
CTTCTTGGTGTCTGGCCTGGGCGGTGAACATACCGCGTTCAATCAACTACCTG
GTGGTAAAGCGGAATATCACGGTAAAGCTTTCTCTTCCGACGACCCCAACGGC
CGTTTGCACTACTCCATCGATTTCACCAAAAAACAGGGTTATGGTCGCATTGAA
CACCTGAAAACCCTGGAGCAAAATGTAGAATTGGCCGCTGCCGAACTGAAGGC
TGACGAAAAATCTCACGCCGTTATCCTGGGTGATACCCGCTACGGTTCTGAAG
AAAAAGGCACTTACCACCTGGCCCTGTTTGGCGACCGTGCGCAAGAAATTGCC
GGCAGCGCCACCGTCAAAATCGGTGAAAAAGTCCACGAAATCGGCATTGCGG
GCAAGCAA

FIG. 22

fHbp ID 1

GGTGTTGCGGCCGACATCGGCGCCGGGCTGGCCGACGCGCTGACGGCGCCT
CTGGACCACAAAGACAAAGGCTTGCAGTCTTTGACTCTGGACCAATCTGTACG
CAAGAACGAAAAACTCAAACTGGCCGCTCAAGGTGCGGAAAAGACCTACGGCA
ACGGCGACAGCCTGAACACTGGCAAACTGAAAAACGACAAAGTGTCTCGCTTT
GACTTCATCCGTCAAATTGAAGTCGACGGCCAGTTGATTACCTTAGAATCCGGC
GAATTCCAAGTTTACAAACAGTCTCACAGCGCCTTGACGGCGTTCCAGACTGAA
CAAATCCAAGATAGCGAACACTCTGGCAAAATGGTTGCCAAACGCCAGTTTCG
CATCGGCGACATCGCAGGTGAACACACTAGCTTCGATAAACTGCCGGAAGGCG
GCCGCGCCACCTACCGCGGTACCGCGTTCGGCAGCGACGATGCCGGTGGCAA
ATTGACTTATACCATTGATTTTGCCGCAAAACAAGGCAACGGCAAAATTGAACA
CTTGAAATCTCCTGAACTGAACGTAGACCTCGCGGCAGCAGACATCAAGCCGG
ATGGTAAGCGCCACGCTGTGATCAGCGGCAGCGTTTTGTACAACCAAGCAGAA
AAAGGCTCCTATTCCTTAGGCATCTTCGGCGGCAAAGCACAAGAGGTAGCCGG
CTCGGCCGAAGTAAAAACTGTGAACGGCATCCGCCACATCGGTCTGGCCGCCA
AACAA

FIG. 23

fHbp ID 14

GGGGTCGCTGCAGACATTGGCGCTGGCCTGGCCGATGCCTTGACCGCGCCGC
TGGATCACAAAGACAAATCCTTGCAAAGTTTGACTCTGGACCAATCCGTGCGCA
AAAATGAAAAACTGAAGCTGGCGGCTCAAGGCGCGGAGAAAACCTATGGCAAC
GGCGATAGCCTGAACACTGGCAAACTGAAAAATGACAAAGTAAGCCGTTTCGA
CTTTATCCGCCAAATTGAAGTTGACGGCCAATTGATTACCCTGGAATCCGGCGA
ATTCCAAGTGTACAAACAATCTCACAGCGCTTTGACCGCACTCCAAACCGAGCA
AGAACAAGACCCTGAACACTCGGGTAAAATGGTCGCGAAACGCCGTTTTAAAAT
CGGCGATATCGCCGGTGAACACACGAGCTTCGATAAATTGCCGAAGGATGTTA
TGGCGACCTACCGCGGCACTGCCTTTGGCTCCGACGACGCCGGCGGTAAATT
GACCTACACTATTGACTTCGCCGCCAAACAAGGTCACGGCAAGATTGAACACC
TGAAAAGCCCGGAACTCAACGTGGAACTGGCAACCGCATACATCAAACCGGAT
GAGAAACACCACGCGGTTATCTCTGGCAGCGTCCTGTACAATCAAGATGAAAA
AGGCTCCTACTCTTTGGGTATCTTCGGTGGTCAAGCTCAAGAAGTAGCGGGCT
CGGCGGAAGTGGAAACCGCCAACGGCATTCACCACATTGGCCTGGCAGCGAA
ACAG

FIG. 24

fHbp ID 45

GGCGTCGCGGCCGACATTGGCGCCGGTTTGGCGGACGCGCTCACCGCTCCGT
TGGACCATAAAGATAAAGGCTTGCAATCCCTGACGTTGGATCAAAGCGTTCGCA
AAAACGAAAAACTGAAATTGGCCGCGCAAGGTGCTGAAAAAACCTACGGTAAC
GGTGACTCTTTGAACACCGGTAAATTAAAAAACGATAAAGTCAGCCGTTTCGAC
TTTATCCGCCAAATTGAAGTTGACGGTAAATTGATTACCTTGGAAAGCGGCGAA
TTCCAAGTCTACAAACAAAGCCACAGCGCCCTGACCGCTTTGCAAACGGAACA
AGTTCAAGATTCCGAAGACTCCGGCAAAATGGTTGCAAAACGCCAGTTCCGTAT
CGGGGATATCGCGGGCGAACACACCAGCTTCGACAAATTGCCTAAAGGTGGTT
CGGCAACCTATCGCGGTACCGCCTTCGGTTCTGATGACGCGGGTGGCAAATTA
ACCTATACCATTGATTTCGCTGCCAAACAAGGCCATGGTAAAATCGAGCACTTG
AAATCACCGGAGCTGAACGTTGAACTGGCCACGGCCTACATCAAACCGGACGA
AAAACGCCACGCCGTAATCTCCGGTTCTGTTTTGTACAACCAAGATGAAAAAGG
CTCCTATTCTTTGGGCATTTTCGGCGGCCAAGCCCAAGAAGTGGCGGGCTCTG
CAGAAGTCGAAACCGCAAACGGCATCCGTCACATTGGTCTGGCCGCAAAACAG

FIG. 25

fHbp ID 55

GGTGTCGCGGCCGACATCGGTGCTGGCCTGGCTGACGCCCTGACCGCACCTT
TGGACCACAAAGACAAAGGCTTGCAATCCCTGATGCTGGACCAATCCGTCCGG
AAGAACGAAAAATTGAAGTTGGCGGCCCAGGGCGCTGAAAAAACCTACGGTAA
TGGTGACTCCCTGAACACTGGCAAACTGAAAAACGATAAAGTGTCCCGCTTTGA
CTTCATTCGCCAAATTGAAGTGGATGGTAAACTGATTACCCTGGAAAGCGGCGA
ATTCCAAATTTACAAACAAGACCATAGCGCGGTCGTGGCACTGCAAATCGAAAA
AATTAACAACCCCGACAAAATCGATTCTTTGATCAATCAGCGCTCCTTCTTGGTC
AGCGGCTTGGGCGGCGAGCACACCGCATTTAACCAATTGCCTAGCGGCAAAG
CAGAATACCACGGTAAAGCGTTTTCCTCAGACGACGCAGGTGGCAAATTGACC
TACACCATTGATTTTGCCGCCAAACAAGGTCATGGCAAAATCGAACACCTGAAA
ACTCCGGAGCAAAATGTAGAGCTGGCATCCGCCGAACTGAAAGCCGACGAAAA
ATCTCACGCAGTGATCTTGGGCGACACGCGTTATGGCGGCGAAGAAAAAGGCA
CCTACCACCTGGCCCTGTTCGGTGACCGTGCACAAGAAATTGCAGGTAGCGCC
ACTGTGAAAATCCGCGAGAAAGTACACGAAATTGGCATTGCAGGTAAACAA

FIG. 26

fHbp ID 19

GGTGTGGCGGCGGACATCGGCGCTGGCTTGGCCGACGCGCTGACGGCGCCT
CTGGATCATAAAGATAAAAGCCTGCAATCTTTGACGTTGGACCAATCTGTCCGT
AAAAATGAAAAACTGAAGTTGGCCGCGCAGGGCGCAGAAAAGACTTATGGTAA
CGGTGACTCTTTAAATACCGGCAAACTGAAAAACGATAAAGTCTCCCGCTTTGA
TTTCATCCGCCAAATTGAGGTCGATGGCCAATTGATCACGCTGGAGTCTGGCG
AATTCCAAATCTACAAACAAGACCATTCCGCTGTTGTGGCTCTGCAAATCGAAA
AAATCAATAACCCCGACAAAATCGACTCTTTGATCAACCAACGTAGCTTCCTCG
TATCTGGTCTGGGCGGTGAGCACACCGCGTTCAACCAATTGCCCAGCGGTAAG
GCCGAATACCATGGCAAAGCGTTCTCTTCTGACGATGCAGGTGGTAAACTGAC
CTACACCATTGATTTCGCAGCTAAACAAGGCCATGGTAAAATCGAACATCTGAA
AACCCCGGAACAGAATGTAGAGCTGGCATCTGCAGAACTGAAAGCCGACGAGA
AATCACACGCCGTAATCCTGGGCGATACCCGCTACGGTGGTGAAGAAAAAGGC
ACCTATCACTTGGCACTGTTCGGTGACCGTGCACAAGAAATCGCTGGTTCTGCA
ACCGTGAAAATTCGTGAAAAAGTACACGAAATTGGCATTGCCGGAAAACAA

FIG. 27

fHbp ID 77

GGCGTAGCCGCTGATATCGGCGCCGGCCTGGCGGATGCGTTGACAGCACCGC
TGGACCATAAAGATAAAGGTCTGCAATCCCTGACCTTGGATCAAAGCGTACGTA
AAAACGAAAAATTGAAACTAGCCGCCCAAGGTGCGGAAAAAACCTACGGTAAC
GGCGATTCTTTGAACACGGGCAAATTGAAAAATGACAAAGTCTCCCGCTTTGAC
TTCATCCGCCAAATTGAAGTTGACGGAAAATTGATTACCCTGGAAAGCGGTGAA
TTCCAAGTATACAAACAAAGCCACTCTGCCTTGACCGCATTGCAGACCGAACAA
GTGCAAGACAGCGAAGATAGCGGCAAAATGGTTGCCAAACGCCAATTCCGCAT
TGGTGACATAGCCGGCGAACACACCAGTTTCGACAAACTGCCTAAAGGCGGTT
CTGCTACTTACCGTGGCACAGCCTTGGGCTCCGACGACGCCGGCGGTAAATTG
ACCTACACTATCGACTTCGCCGCCAAACAAGGCCACGGCAAAATCGAGCACTT
GAAATCACCGGAATTGAACGTCGAATTGGCCACCGCCTACATCAAACCGGACG
AAAAACGTCATGCCGTGATTTCTGGCTCTGTTTTGTACAACCAAGACGAGAAAG
GCAGCTACAGCTTGGGTATTTTCGGCGGTCAAGCCCAAGAAGTTGCGGGCTCC
GCAGAAGTAGAAACCGTGAACGGCATTCACCACATTGGCCTGGCTGCAAAACA
A

FIG. 28

NspA (nmb0663)

ATGAAAAAAGCCCTGGCCACCCTGATTGCGCTGGCACTGCCTGCGGCGGCAC
TCGCCGAAGGCGCAAGCGGTTTCTACGTGCAAGCCGATGCCGCACACGCCAA
AGCCTCGTCCTCCCTGGGTTCTGCCAAAGGCTTTTCTCCTCGCATCAGCGCCG
GTTACCGTATCAACGATCTGAGGTTTGCCGTAGACTACACGCGTTATAAAAACT
ACAAAGCACCCAGCACTGACTTCAAATTGTACTCTATCGGCGCGTCTGCTATCT
ATGATTTCGACACCCAATCCCCGGTTAAACCTTACTTGGGAGCCCGTTTGTCCT
TGAACCGCGCATCCGTGGACCTGGGTGGCAGCGACTCCTTTTCACAAACCAGC
ATCGGTCTGGGCGTGCTGACCGGTGTAAGCTACGCTGTCACGCCTAACGTAGA
TCTGGACGCCGGTTACCGTTACAATTACATTGGTAAAGTTAACACTGTGAAAAA
TGTACGCTCCGGCGAACTGTCCGCGGGCGTCCGCGTAAAATTCTGA

FIG. 29

NspA (nmc0612, nma0862)

ATGAAAAAAGCCTTGGCCACCTTGATCGCCTTGGCCTTGCCGGCCGCCGCCTT
GGCCGAAGGCGCCTCCGGCTTCTACGTTCAAGCCGACGCCGCCCACGCCAAA
GCCTCCTCCTCCTTGGGCTCCGCCAAAGGCTTCTCCCCGCGCATCTCCGCCGG
CTACCGCATCAACGACTTGCGCTTCGCCGTTGACTACACCCGCTACAAAAACTA
CAAAGCCCCGTCCACCGACTTCAAATTGTACTCCATCGGCGCCTCCGCCATCT
ACGACTTCGACACCCAATCCCCGGTTAAACCGTACTTGGGCGCCCGCTTGTCC
TTGAACCGCGCCTCCGTTGACTTGGGCGGCTCCGACTCCTTCTCCCAAACCTC
CACCGGCTTGGGCGTTTTGGCCGGCGTTTCCTACGCCGTTACCCCGAACGTTG
ACTTGGACGCCGGCTACCGCTACAACTACATCGGCAAAGTTAACACCGTTAAAA
ACGTTCGCTCCGGCGAATTGTCCGCCGGCGTTCGCGTTAAATTCTGA

FIG. 30

NHbp(nmb2132)

ATGTTTAAGCGTTCCGTTATTGCTATGGCCTGCATTTTCGCCTTGTCCGCCTGC
GGTGGCGGTGGTGGCGGCAGCCCCGACGTAAAATCTGCCGACACCTTGAGCA
AACCCGCTGCGCCTGTTGTATCTGAAAAAGAAACCGAAGCGAAAGAAGATGCT
CCGCAGGCGGGCTCCCAAGGTCAAGGCGCACCTTCTGCCCAAGGCTCACAAG
ACATGGCCGCGGTGTCCGAAGAAAATACCGGTAATGGTGGCGCTGTTACCGCA
GACAATCCGAAAAACGAAGATGAAGTTGCTCAAAACGACATGCCACAGAACGC
CGCCGGCACTGACTCTTCCACCCCCAACCACACCCCTGACCCTAATATGTTGG
CCGGCAACATGGAAAACCAAGCCACCGACGCAGGCGAGTCCAGCCAACCC
GCCAACCAGCCTGATATGGCGAACGCGGCCGACGGTATGCAAGGCGATGACC
CGAGCGCAGGCGGTCAAAACGCGGGCAACACCGCCGCCCAAGGCGCTAACCA
GGCTGGTAACAACCAAGCCGCAGGCAGCAGCGACCCGATCCCGGCATCAAAC
CCGGCACCTGCAAACGGCGGAAGCAACTTCGGCCGCGTTGACTTGGCAAACG
GCGTGCTGATCGACGGCCCGTCTCAAAACATCACCTTGACCCATTGTAAAGGC
GACTCTTGCTCCGGCAACAATTTCCTGGACGAGGAAGTCCAGTTGAAATCCGA
ATTTGAAAAGCTGAGCGACGCGGATAAAATTTCTAACTATAAAAAAGACGGCAA
AAACGACAAATTCGTAGGCCTGGTTGCCGATAGTGTGCAGATGAAAGGCATC
AACCAATACATTATCTTCTATAAACCGAAACCTACCTCCTTCGCTCGTTTCCGCC
GTAGCGCCCGCTCCCGCCGTTCCTTGCCGGCCGAAATGCCCCTGATCCCCGT
AAACCAAGCTGACACTTTGATCGTAGATGGCGAGGCAGTTTCTCTCACCGGCC
ACAGCGGCAATATTTTCGCACCCGAAGGTAACTACCGCTACCTGACTTATGGC
GCCGAAAAACTGCCGGGTGGCTCTTATGCGCTGCGCGTCCAAGGCGAGCCGG
CAAAAGGTGAAATGTTGGCCGGCGCTGCCGTATATAACGGCGAAGTGTTGCAC
TTCCATACCGAAAACGGTCGCCCGTACCCGACCCGCGGCCGATTTGCTGCTAA
AGTCGACTTCGGCAGCAAAAGTGTTGACGGTATTATCGACTCAGGCGACGATT
TGCACATGGGTACGCAAAAATTCAAAGCCGCGATCGACGGTAATGGCTTCAAA
GGCACCTGGACGGAAAACGGTTCTGGTGACGTTTCTGGTAAATTCTACGGCCC
CGCCGGCGAAGAGGTCGCGGGCAAATATTCATACCGCCCTACCGACGCCGAA
AAAGGGGGCTTTGGTGTTTTCGCCGGTAAAAAAGAACAAGACTGA

FIG. 31

TbpB (Tbp2, nmb0461)

ATGAACAACCCGTTGGTTAACCAAGCCGCCATGGTTTTGCCGGTTTTCTTGTTGTCCGCCTGCTT
GGGCGGCGGCGGCTCCTTCGACTTGGACTCCGTTGACACCGAAGCCCCGCGCCCGGCCCCGA
AATACCAAGACGTTTTCTCCGAAAAACCGCAAGCCCAAAAAGACCAAGGCGGCTACGGCTTCGC
CATGCGCTTGAAACGCCGCAACTGGTACCCGCAAGCCAAAGAAGACGAAGTTAAATTGGACGAA
TCCGACTGGGAAGCCACCGGCTTGCCGGACGAACCGAAAGAATTGCCGAAACGCCAAAAATCC
GTTATCGAAAAAGTTGAAACCGACTCCGACAACAACATCTACTCCTCCCCGTACTTGAAACCGTC
CAACCACCAAAACGGCAACACCGGCAACGGCATCAACCAACCGAAAAACCAAGCCAAAGACTAC
GAAAACTTCAAATACGTTTACTCCGGCTGGTTCTACAAACACGCCAAACGCGAATTCAACTTGAA
AGTTGAACCGAAATCCGCCAAAAACGGCGACGACGGCTACATCTTCTACCACGGCAAAGAACCG
TCCCGCCAATTGCCGGCCTCCGGCAAAATCACCTACAAAGGCGTTTGGCACTTCGCCACCGACA
CCAAAAAAGGCCAAAAATTCCGCGAAATCATCCAACCGTCCAAATCCCAAGGCGACCGCTACTC
CGGCTTCTCCGGCGACGACGGCGAAGAATACTCCAACAAAAACAAATCCACCTTGACCGACGG
CCAAGAAGGCTACGGCTTCACCTCCAACTTGGAAGTTGACTTCCACAACAAAAAATTGACCGGC
AAATTGATCCGCAACAACGCCAACACCGACAACAACCAAGCCACCACCACCCAATACTACTCCTT
GGAAGCCCAAGTTACCGGCAACCGCTTCAACGGCAAAGCCACCGCCACCGACAAACCGCAACA
AAACTCCGAAACCAAAGAACACCCGTTCGTTTCCGACTCCTCCTCCTTGTCCGGCGGCTTCTTC
GGCCCGCAAGGCGAAGAATTGGGCTTCCGCTTCTTGTCCGACGACCAAAAAGTTGCCGTTGTTG
GCTCCGCCAAAACCAAAGACAAACCGGCCAACGGCAACACCGCCGCCGCCTCCGGCGGCACC
GACGCCGCCGCCTCCAACGGCGCCGCCGGCACCTCCTCCGAAAACGGCAAATTGACCACCGTT
TTGGACGCCGTTGAATTGAAATTGGGCGACAAAGAAGTTCAAAAATTGGACAACTTCTCCAACGC
CGCCCAATTGGTTGTTGACGGCATCATGATCCCGTTGTTGCCGGAAGCCTCCGAATCCGGCAAC
AACCAAGCCAACCAAGGCACCAACGGCGGCACCGCCTTCACCCGCAAATTCGACCACACCCCG
GAATCCGACAAAAAAGACGCCCAAGCCGGCACCCAAACCAACGGCGCCCAAACCGCCTCCAAC
ACCGCCGGCGACACCAACGGCAAAACCAAAACCTACGAAGTTGAAGTTTGCTGCTCCAACTTGA
ACTACTTGAAATACGGCATGTTGACCCGCAAAAACTCCAAATCCGCCATGCAAGCCGGCGAATC
CTCCTCCCAAGCCGACGCCAAAACCGAACAAGTTGAACAATCCATGTTCTTGCAAGGCGAACGC
ACCGACGAAAAAGAAATCCCGTCCGAACAAAACATCGTTTACCGCGGCTCCTGGTACGGCTACA
TCGCCAACGACAAATCCACCTCCTGGTCCGGCAACGCCTCCAACGCCACCTCCGGCAACCGCG
CCGAATTCACCGTTAACTTCGCCGACAAAAAAATCACCGGCACCTTGACCGCCGACAACCGCCA
AGAAGCCACCTTCACCATCGACGGCAACATCAAAGACAACGGCTTCGAAGGCACCGCCAAAACC
GCCGAATCCGGCTTCGACTTGGACCAATCCAACACCACCCGCACCCCGAAAGCCTACATCACC
GACGCCAAAGTTCAAGGCGGCTTCTACGGCCCGAAAGCCGAAGAATTGGGCGGCTGGTTCGCC
TACCCGGGCGACAAACAAACCAAAAACGCCACCAACGCCTCCGGCAACTCCTCCGCCACCGTT
GTTTTCGGCGCCAAACGCCAACAACCGGTTCGCTAA

FIG. 32

TbpA (Tbp1, nmb0461)

ATGCAGCAACAACACCTGTTCCGCTTCAACATTCTGTGCCTGAGCCTGATGACTGCCCTG
CCTGCGTACGCGGAGAACGTACAAGCCGGCCAAGCCCAAGAAAAACAGCTGGACACCATC
CAAGTAAAAGCCAAAAAACAAAAAACTCGCCGCGATAACGAGGTTACCGGTCTGGGCAAA
TTGGTGAAATCGTCGGACACCTTGAGCAAGGAGCAAGTATTGAATATTCGTGACCTGACC
CGCTACGACCCTGGTATCGCCGTCGTAGAACAGGGCCGTGGCGCAAGCTCAGGTTATTCC
ATTCGTGGTATGGACAAAAATCGCGTAAGCCTGACCGTTGACGGCGTCTCCCAGATCCAG
TCTTACACAGCCCAAGCCGCTCTGGGCGGTACCCGCACCGCCGGCAGCTCAGGCGCCATT
AACGAAATCGAATACGAAAATGTTAAAGCAGTTGAAATTAGCAAAGGCTCCAACTCCGTT
GAGCAAGGCTCCGGCGCCTTGGCCGGCAGCGTAGCCTTTCAAACTAAAACCGCTGATGAC
GTGATTGGCGAAGGTCGTCAATGGGGCATCCAATCGAAAACCGCTTACAGCGGCAAAAAC
CGCGGCTTGACCCAATCTATCGCATTGGCGGGTCGTATTGGCGGTGCCGAGGCACTGCTG
ATCCACACCGGTCGTCGCGCAGGCGAAATCCGCGCCCACGAAGATGCCGGCAGGGGTGTT
CAGTCCTTTAACCGCTTGGTTCCCGTGGAAGATTCATCGAACTACGCATACTTCATCGTG
AAAGAAGAATGCAAAAACGGTAGCTACGAAACGTGCAAAGCTAACCCTAAAAAGGACGTT
GTTGGCAAGGACGAACGCCAAACTGTTAGCACTCGTGATTACACCGGTCCCAACCGCTTT
CTGGCAGACCCGCTGTCATATGAATCCCGCTCCTGGCTCTTCCGCCCGGGTTTCCGCTTC
GAGAACAAACGACACTATATTGGGGGCATCTTGGAACACACTCAACAAACCTTCGACACC
CGTGATATGACAGTACCCGCCTTCTTGACCAAAGCTGTCTTCGATGCGAACAAAAAACAA
GCGGGTTCTCTACCTGGCAATGGTAAATACGCCGGCAATCACAAATACGGCGGTCTGTTT
ACCAACGGTGAAAACGGTGCATTGGTCGGCGCCGAATACGGCACGGGCGTCTTTTACGAC
GAGACCCATACGAAAAGTCGCTACGGCTTGGAGTATGTTTATACAAACGCCGACAAAGAC
ACGTGGGCCGACTACGCCCGCTTGTCTTACGACCGTCAGGGTATTGGCCTGGACAACCAC
TTTCAACAAACTCACTGCTCCGCGGACGGGAGCGACAAATATTGCCGCCCTTCTGCGGAC
AAACCGTTCTCCTACTACAAATCCGATCGCGTGATCTATGGCGAAAGTCATCGACTGTTA
CAGGCCGCGTTCAAAAAAAGCTTCGACACCGCCAAAATTCGTCACAATCTGTCGGTCAAT
TTGGGCTTCGACCGCTTCGGTAGCAACCTGCGTCACCAAGATTACTATTACCAACATGCT
AATCGCGCCTACTCAAGTAACACCCCCCCTCAAAACAACGGCAAAAAAATCTCACCCAAC
GGCTCCGAAACTTCCCCTTACTGGGTGACCATTGGTCGTGGCAACGTAGTTACTGGCCAA
ATTTGCCGTCTGGGTAACAATACCTATACCGATTGCACTCCGCGCTCAATCAACGGCAAA
AGCTACTACGCAGCCGTTCGCGACAACGTCCGCCTCGGCCGTTGGGCAGACGTCGGCGCT
GGTCTGCGCTACGACTACCGCTCTACTCACAGCGACGACGGCAGTGTGAGTACTGGTACT
CACCGTACCTTGTCCTGGAATGCCGGCATCGTCCTCAAACCTACCGACTGGCTGGATTTG
ACCTACCGTACATCCACCGGCTTTCGTTTGCCTTCATTCGCGGAGATGTACGGTTGGCGT
GCAGGCGTACAAAGCAAAGCTGTGAAAATTGATCCGGAAAAATCCTTCAATAAAGAAGCT
GGCATCGTATTCAAAGGCGACTTCGGCAACCTGGAAGCATCCTGGTTCAACAACGCCTAT
CGTGACCTGATTGTGCGTGGCTATGAAGCCCAAATTAAAGACGGCAAAGAAGAAGCGAAA
GGCGACCCGGCTTACCTGAACGCGCAATCTGCGCGCATCACCGGCATCAATATCCTGGGC
AAAATCGACTGGAACGGCGTGTGGGATAAACTGCCCGAAGGCTGGTACTCCACTTTCGCT
TATAACCGCGTGCGTGTCCGCGATATCAAAAAACGTGCTGACCGCACAGATATCCAATCT
CACTTATTCGATGCAATTCAACCTTCCCGCTATGTCGTTGGCTTGGGTTATGACCAACCT
GAAGGTAAATGGGGCGTGAATGGCATGTTGACTTACTCCAAAGCCAAAGAGATTACCGAA
CTGTTGGGCTCTCGTGCGTTGTTGAACGGCAACAGCCGTAACACTAAAGCAACCGCGCGT
CGCACGCGCCCTTGGTATATTGTCGATGTATCAGGTTACTATACCGTTAAAAAACACTTC
ACCCTGCGCGCCGGCGTTTACAATTTGTTGAACTATCGTTATGTCACCTGGGAAAATGTA
CGTCAAACCGCTGGAGGCGCCGTTAACCAACATAAAAACGTGGGCGTTTACAACCGTTAC
GCGGCGCCAGGTCGTAACTACACCTTCAGCTTGGAAATGAAATTCTAA

FIG. 33

LbpB (nmb1541)

ATGTGCAAACCCAATTACGGTGGTATCGTGTTGTTGCCCTTGCTGCTGGCTTCCTGTATT
GGCGGCAACTTTGGCGTACAACCGGTAGTTGAAAGCACCCCTACTGCGTACCCAGTGACC
TTCAAATCTAAAGACGTTCCGACCCCGCCGCCGGCCGGTTCCAGCGTGGAAACAACCCCA
GTTAACCGCCCGGCAGTAGGCGCCGCTATGCGTCTCCCGCGCCGCAATATCGCTAGCTAC
AAACAGGACGGCACTGAAATCCCTGACAAACACCAAGCAGAAGAACACCTGCCTCTGAAA
GAAAAAGACATCCTGTTCCTGGACGGCACCCTGAAAGAACAAGCAGACAAATTGAAAAAG
AAAATCAACGAACGCTATAGCGATGTTCGCGTTATTACCTCCAAAAAAGAAGAAGAGAAA
TACCAATACCAATTCGTACGCGCGGGTTACGTGTTCACGCGCGCCGAAGGCAAAGACAAC
GAAAAAGAAAAAACCTCTGATGGCAAAGAATTCGTCAACCGCTTCTCCTACGACGGTTTC
GTTTATTACTCTGGCGAACGCCCTTCCCAATCGTTGCCTTCCGCAGGCACCGTGCAATAT
AGCGGCAACTGGCAATATATGACCGACGCAAAACGCCACCGCACTGGCAAAGCAGTCTCA
AGCACTGACTTGGGCTACACCACGTACTACGGTAACGAAATCGGTGCCACCTCCTACGAA
GCTCGCGACGCGGACGACCGCGAAAAACACCCTGCTGAATATACTGTCGACTTCGACAAT
AAAACCCTGAACGGCAAACTGATCAAAAACCAGTACGTTCAAAACAAAAGCAACCCCAAC
GAACCGAAAAAACCGTTGACCATCTACGACATCACTGCCACCCTGGATGGTAACCGCTTC
ACCGGCTCCGCAAAGGTATCCACCGAAGTGAAAACCCAACACGCTGATAAAGAATACCTG
TTTTTCCACACCGATGCCGACCAACGCTTGGAAGGCGGCTTCTTCGGCGACAACGGCGAA
GAATTGGCCGGACGCTTCATTTCGAACGATAACTCTGTGTTTGGCGTTTTCGCTGGCAAA
CAAAAAACTGAAACCGAAAATGCGGCTGACACAAAACCGGCCCTCTCAAGCGGCAAACAC
ACTAAAATCCTGGACTCTCTGAAAATTTCCGTTGACGAAGCTAGCGACAAAAACCCGCGC
GAATTCGCTATCTCGAGTATGCCCGACTTTGGTCACCCGGACAAACTGTTGGTCGAAGGT
CGCGAAATCCCTCTGGTGAACAAAGAACAAACCATCGAGCTGGCAGACGGCCGCAAAACT
ACTATTCGCACGTGCTGTGACTTCCTCACTTACGTCAAAATTGGCCGTATGCAAACTGAG
CGCCCGGCCGCAAAACCTAAAGCCCAGGATGAAGAACGTGATGAGGAAGACACCGGTGTG
GACTCAGTTGAAGAGGGCGAAGATGAGATCGATGACGAAGAAGGTACCGAAGACGCAGCC
GTGAAAGACGAAGGCTCCGAAGAAGATGAGGCTGTGGAAGGTGAGGACGAAGCTGAAGAA
CCAGAAGAAGAGTCTCCTACTGAAGAAGGCGGTTCCGGTAGCGACGGCATCTTGCCGGCC
CCTGAAGCCCCGAAAGGTCGTAATATTGACTTGTTCTTGAAAGGCATTCGCACGGCGGAA
ACCGATATTCCGAAAACCGGCGAAGCTCACTACACCGGTACCTGGGAAGCCCGCATCGGC
AAACCGATCCAATGGGACAACCAAGCCGACAAAGAAGCTGCTAAAGCTGTGTTTACCGTT
GACTTCGGCAAAAAATCCATTTCTGGTACCTTGACCGAAGAGAACGGCGTCGAACCCGCG
TTCCACATTGAAAACGGCAAAATCGAAGGCAACGGTTTTTATGCGACCGCCCGTACTCGC
GAGAATGGCATTAATTTGTCTGGCAACGGCTCCACAGATCCGAAAACCTTTCAAGCCTCG
AACTTGCGCGTAGAAGGCGGCTTCTACGGCCCACAAGCAGAAGAGCTGGGTGGTATCATC
TTCAACAACGACGGCAAAAGCCTGGGCATTACCGAGGGCACTGAAAACAAAGTGGACGTA
GAAGCTGAAGTTGATGCTGAAGTTGATGTCGGCAAGCAATTGGAGAGCGAAGTAAAACAC
CAGTTTGGTGTCGTCTTCGGTGCCAAAAAAGACATGCAGGAAGTCGAGAAATGA

FIG. 34

LbpA(nmb1540)

ATGAACAAAAAACACGGCTTTCCGTTGACTCTTACCGCCTTGGCTATCGCCACCGCCTTT
CCGGCTTACGCTGCTCAAGCCGGCGGCGCCACTCCTGACGCAGCGCAAACCCAGTCTCTG
AAAGAAATTACCGTACGTGCTGCTAAAGTAGGTCGCCGCAGCAAAGAAGCTACCGGCTTG
GGCAAAATCGTTAAAACCTCCGAAACCCTCAACAAAGAACAAGTTCTGGGCATTCGCGAC
CTGACTCGCTACGATCCTGGTGTTGCCGTAGTCGAACAAGGTAATGGCGCCTCGGGCGGT
TATAGCATCCGTGGCGTAGATAAAAACCGTGTCGCAGTTAGCGTTGATGGTGTTGCCCAA
ATCCAAGCATTTACCGTGCAAGGTTCCTTGTCCGGCTACGGTGGTCGCGGCGGTTCCGGC
GCCATCAATGAAATCGAATACGAAAACATATCCACTGTAGAGATTGATAAAGGTGCAGGT
TCCAGCGATCACGGTTCTGGCGCACTGGGTGGCGCTGTTGCATTCCGCACAAAAGAAGCC
GCCGACTTGATTAGCGACGGCAAAAGCTGGGGTATTCAAGCCAAAACTGCCTACGGCTCT
AAGAACCGTCAATTCATGAAAAGCTTGGGTGCTGGCTTTTCCAAAGATGGTTGGGAAGGT
CTGCTGATCCGCACTGAACGTCAAGGTAGGGAAACCCGTCCGCACGGTGACATTGCTGAT
GGCGTTGAATACGGCATTGACCGTCTGGACGCCTTCCGCCAAACCTACGATATCAAACGC
AAAACCAGAGAGCCCTTCTTTTCTGTCGAAGGTGAGCGCGAATCAAAACCTGTCGCCAAA
CTGGCAGGCTACGGTAAATACCTGAACAATCAATTGAACCGTTGGGTTAAAGAACGTATT
GAACAAAATCAGCCCCTGTCTGCAGAAGAAGAGGCTCAAGTCCGCGAAGCACAAGCTCGT
CACGAAAACTTGAGCGCACAAGCCTACACCGGCGGCGGACGCATTTTGCCTGACCCTATG
GATTATCGCTCCGGCAGCTGGTTGGCCAAGCTCGGCTACCGTTTTGGTGGCCGCCACTAC
GTTGGTGGTGTTTTCGAAGACACGAAGCAACGTTATGATATCCGCGACATGACTGAAAAA
CAATACTATGGCACCGATGAAGCCGAGAAATTTCGTGATAAATCCGGCGTATATGACGGC
GATGATTTCCGTGACGGTTTGTACTTCGTTCCGAACATCGAAGAATGGAAAGGCGATAAA
AATTTGGTGCGTGGCATTGGTTTGAAATATTCTCGCACCAAATTCATTGATGAACACCAC
CGTCGTCGTCGTATGGGTCTGCTGTATCGCTACGAAAATGAAGCCTACTCCGACAATTGG
GCGGATAAAGCCGTTTTGTCCTTCGATAAGCAGGGTGTTGCTACCGATAACAATACCCTC
AAACTGAACTGCGCTGTTTACCCCGCTGTGGATAAATCTTGCCGTGCCTCAGCCGACAAA
CCATACTCTTACGACTCCAGCGATCGCTTCCACTACCGCGAACAACACAACGTTTTGAAC
GCGTCTTTCGAAAAATCTTTGAAAAACAAATGGACTAAACATCACTTGACCCTGGGTTTT
GGTTACGACGCATCTAAAGCTATCAGCCGTCCGGAACAATTGAGCCATAACGCCGCCCGG
ATTTCCGAAAGCACCGGTTTCGATGAAAATAACCAGGACAAATACTTGTTGGGCAAGCCT
GAGGTCGTGGAAGGCTCAGTCTGCGGCTACATTGAAACCTTGCGCTCTCGTAAATGTGTT
CCTCGCAAAATCAATGGTTCTAACATCCACATCAGCTTGAACGATCGTTTCTCCATCGGC
AAATACTTTGACTTCAGCCTGGGCGGCCGTTACGACCGCAAAAACTTCACTACGTCCGAG
GAGCTGGTACGTTCCGGCCGCTATGTTGACCGTAGCTGGAATTCAGGCATTTTGTTCAAA
CCGAATCGCCACTTCAGCGTTAGCTACCGCGCGTCGTCCGGCTTTCGCACCCCGAGCTTC
CAAGAACTCTTCGGTATTGATATTTACCACGACTACCCTAAAGGCTGGCAACGCCCGGCG
TTGAAATCCGAAAAAGCAGCTAATCGCGAAATCGGCTTGCAATGGAAAGGCGACTTCGGT
TTCCTGGAAATCTCCTCTTTCCGCAACCGTTACACGGATATGATCGCAGTCGCAGACCAC
AAAACCAAACTGCCGAACCAAGCCGGCCAACTGACCGAAATTGATATCCGCGACTACTAT
AACGCACAAAACATGTCATTGCAAGGTGTTAATATCCTGGGCAAAATCGACTGGAATGGC
GTCTATGGCAAATTGCCGGAAGGCCTCTATACGACCCTGGCTTATAACCGCATCAAACCG
AAAAGCGTGTCCAACCGCCCTGGGTTGTCCCTGCGCTCCTACGCACTGGACGCCGTACAA
CCATCGCGCTACGTACTGGGCTTCGGCTACGACCAACCCGAAGGCAAATGGGGAGCGAAC
ATCATGTTGACTTACAGTAAGGGTAAAAACCCAGACGAATTGGCTTATCTGGCGGGCGAC
CAAAAACGCTATTCCACCAAGCGCGCCAGCAGCAGCTGGAGCACAGCCGACGTGTCAGCA
TACTTGAACCTGAAAAAACGCTTGACCTTGCGCGCTGCCATTTATAACATCGGTAATTAT
CGCTATGTGACCTGGGAAAGCCTGCGCCAAACCGCTGAAAGCACCGCTAACCGCCACGGC
GGCGATAGCAATTACGGTCGTTATGCTGCCCCTGGTCGTAATTTCTCCCTGGCACTGGAA
ATGAAATTCTAA

FIG. 35

Opacity protein (Class 5,nmb1053)

ATGAAAAAGACCGTTTTTACCTGTGCCATGATTGCACTGACCGGTACCGCTGCG
GCCGCCCAGGAATTGCAAACCGCGAACGAATTCACCGTTCATACTGACCTCTC
TTCTATTTCCTCCACTCGTGCCTTCTTGAAAGAAAAACACAAAGCAGCCAAACA
CATCTCTGTACGCGCCGACATTCCTTTCGATGCCAATCAAGGTATTCGCCTGGA
AGCCGGTTTTGGTCGCTCCAAAAAAAACATTATCAATCTGGAAACCGACGAAAA
CAAGCTGGGCAAAACTAAAAACGTAAAACTGCCCACCGGTGTACCCGAAAATC
GTATCGACCTTTACACCGGTTACACCTATACACAGACCCTCAGCGACTCCTTGA
ACTTCCGCGTTGGTGCAGGCTTGGGCTTTGAGTCTTCCAAGGACTCGATCAAA
ACTACCAAACACACCCTCCACTCCTCTCGTCAGTCATGGTTGGCCAAAGTACAC
GCCGATCTGTTGTCCCAATTGGGCAACGGCTGGTATATTAACCCTTGGTCTGAG
GTTAAATTCGACTTGAACTCTCGCTACAAATTGAACACAGGCGTCACAAACCTG
AAAAAAGACATTAACCAAAAAACAAACGGCTGGGGCTTCGGCTTGGGCGCCAA
CATTGGCAAAAAACTGGGCGAAAGCGCTTCCATCGAGGCCGGTCCGTTCTACA
AACAACGTACCTACAAAGAATCCGGTGAATTCTCTGTCACTACTAAATCCGGAG
ACGTATCTTTGACAATCCCTAAAACTTCCATCCGCGAGTATGGCTTGCGCGTCG
GCATCAAATTTTGA

FIG. 36

NadA (nmb1994)

ATGTCCATGAAACACTTCCCGTCCAAAGTTTTGACCACCGCCATCTTGGCCACC
TTCTGCTCCGGCGCCTTGGCCGCCACCTCCGACGACGACGTTAAAAAAGCCGC
CACCGTTGCCATCGTTGCCGCCTACAACAACGGCCAAGAAATCAACGGCTTCA
AAGCCGGCGAAACCATCTACGACATCGGCGAAGACGGCACCATCACCCAAAAA
GACGCCACCGCCGCCGACGTTGAAGCCGACGACTTCAAAGGCTTGGGCTTGA
AAAAAGTTGTTACCAACTTGACCAAAACCGTTAACGAAAACAAACAAAACGTTG
ACGCCAAAGTTAAAGCCGCCGAATCCGAAATCGAAAAATTGACCACCAAATTGG
CCGACACCGACGCCGCCTTGGCCGACACCGACGCCGCCTTGGACGAAACCAC
CAACGCCTTGAACAAATTGGGCGAAAACATCACCACCTTCGCCGAAGAAACCA
AAACCAACATCGTTAAAATCGACGAAAAATTGGAAGCCGTTGCCGACACCGTTG
ACAAACACGCCGAAGCCTTCAACGACATCGCCGACTCCTTGGACGAAACCAAC
ACCAAAGCCGACGAAGCCGTTAAAACCGCCAACGAAGCCAAACAAACCGCCGA
AGAAACCAAACAAAACGTTGACGCCAAAGTTAAAGCCGCCGAAACCGCCGCCG
GCAAAGCCGAAGCCGCCGCCGGCACCGCCAACACCGCCGCCGACAAAGCCG
AAGCCGTTGCCGCCAAAGTTACCGACATCAAAGCCGACATCGCCACCAACAAA
GCCGACATCGCCAAAAACTCCGCCCGCATCGACTCCTTGGACAAAAACGTTGC
CAACTTGCGCAAAGAAACCCGCCAAGGCTTGGCCGAACAAGCCGCCTTGTCC
GGCTTGTTCCAACCGTACAACGTTGGCCGCTTCAACGTTACCGCCGCCGTTGG
CGGCTACAAATCCGAATCCGCCGTTGCCATCGGCACCGGCTTCCGCTTCACCG
AAAACTTCGCCGCCAAAGCCGGCGTTGCCGTTGGCACCTCCTCCGGCTCCTCC
GCCGCCTACCACGTTGGCGTTAACTACGAATGGTAA

FIG. 37

PorA (nmb1429)

ATGCGCAAAAAATTGACCGCCTTGGTTTTGTCCGCCTTGCCGTTGGCCGCCGT
TGCCGACGTTTCCTTGTACGGCGAAATCAAAGCCGGCGTTGAAGGCCGCAACT
ACCAATTGCAATTGACCGAAGCCCAAGCCGCCAACGGCGGCGCCTCCGGCCA
AGTTAAAGTTACCAAAGTTACCAAAGCCAAATCCCGCATCCGCACCAAAATCTC
CGACTTCGGCTCCTTCATCGGCTTCAAAGGCTCCGAAGACTTGGGCGACGGCT
TGAAAGCCGTTTGGCAATTGGAACAAGACGTTTCCGTTGCCGGCGGCGGCGC
CACCCAATGGGGCAACCGCGAATCCTTCATCGGCTTGGCCGGCGAATTCGGC
ACCTTGCGCGCCGGCCGCGTTGCCAACCAATTCGACGACGCCTCCCAAGCC
ATCGACCCGTGGGACTCCAACAACGACGTTGCCTCCCAATTGGGCATCTTCAA
ACGCCACGACGACATGCCGGTTTCCGTTCGCTACGACTCCCCGGAATTCTCCG
GCTTCTCCGGCTCCGTTCAATTCGTTCCGATCCAAAACTCCAAATCCGCCTACA
CCCCGGCCTACTACACCAAAAACACCAACAACAACTTGACCTTGGTTCCGGCC
GTTGTTGGCAAACCGGGCTCCGACGTTTACTACGCCGGCTTGAACTACAAAAA
CGGCGGCTTCGCCGGCAACTACGCCTTCAAATACGCCCGCCACGCCAACGTT
GGCCGCAACGCCTTCGAATTGTTCTTGATCGGCTCCGGCTCCGACCAAGCCAA
AGGCACCGACCCGTTGAAAAACCACCAAGTTCACCGCTTGACCGGCGGCTACG
AAGAAGGCGGCTTGAACTTGGCCTTGGCCGCCCAATTGGACTTGTCCGAAAAC
GGCGACAAAACCAAAAACTCCACCACCGAAATCGCCGCCACCGCCTCCTACCG
CTTCGGCAACGCCGTTCCGCGCATCTCCTACGCCCACGGCTTCGACTTCATCG
AACGCGGCAAAAAAGGCGAAAACACCTCCTACGACCAAATCATCGCCGGCGTT
GACTACGACTTCTCCAAACGCACCTCCGCCATCGTTTCCGGCGCCTGGTTGAA
ACGCAACACCGGCATCGGCAACTACACCCAAATCAACGCCGCCTCCGTTGGCT
TGCGCCACAAATTCTAA

FIG. 38

feta (nmb1988)

ATGAACACCCCGTTGTTCCGCTTGTCCTTGTTGTCCTTGACCTTGGCCGCCGGCTTCGCCCACG
CCGCCGAAAACAACGCCAAAGTTGTTTTGGACACCGTTACCGTTAAAGGCGACCGCCAAGGCTC
CAAAATCCGCACCAACATCGTTACCTTGCAACAAAAAGACGAATCCACCGCCACCGACATGCGC
GAATTGTTGAAAGAAGAACCGTCCATCGACTTCGGCGGCGGCAACGGCACCTCCCAATTCTTGA
CCTTGCGCGGCATGGGCCAAAACTCCGTTGACATCAAAGTTGACAACGCCTACTCCGACTCCCA
AATCTTGTACCACCAAGGCCGCTTCATCGTTGACCCGGCCTTGGTTAAAGTTGTTTCCGTTCAAA
AAGGCGCCGGCTCCGCCTCCGCCGGCATCGGCGCCACCAACGGCGCCATCATCACCAAAACC
GTTGACGCCCAAGACTTGTTGAAAGGCTTGGACAAAAACTGGGGCGTTCGCTTGAACTCCGGCT
TCGCCTCCAACGAAGGCGTTTCCTACGGCGCCTCCGTTTTCGGCAAAGAAGGCAACTTCGACG
GCTTGTTCTCCTACAACCGCAACAACGAAAAAGACTACGAAGCCGGCAAAGGCTTCCGCAACAA
CTTCAACGGCGGCAAAACCGTTCCGTACTCCGCCTTGGACAAACGCTCCTACTTGGCCAAAATC
GGCACCTCCTTCGGCGACGGCGACCACCGCATCGTTTTGTCCCACATGAAAGACCAACACCGC
GGCATCCGCACCGTTCGCGAAGAATTCACCGTTGGCGGCGACAAAGAACGCATCTCCATGGAA
CGCCAAGCCCCGGCCTACCGCGAAACCACCCAATCCAACACCAACTTGGCCTACACCGGCAAA
AACTTGGGCTTCGTTGAAAAATTGGACGCCAACGCCTACGTTTTGGAAAAAGAACGCTACTCCG
CCGACGACTCCGGCACCGGCTACGCCGGCAACGTTAAAGGCCCGAACCACACCCAAATCACCA
CCCGCGGCATGAACTTCAACTTCGACTCCCGCTTGGCCGAACAAACCTTGTTGAAATACGGCAT
CAACTACCGCCACCAAGAAATCAAACCGCAAGCCTTCTTGAACTCCCAATTCAAAATCGAAGACA
AAGAAAAAGCCACCGACGAAGAAAAAAACAAAAACCGCGAAAACGAAAAAATCGCCAAAGCCTA
CCGCTTGACCAACCCGACCAAAACCGACACCGGCGCCTACATCGAAGCCATCCACGAAATCGA
CGGCTTCACCTTGACCGGCGGCTTGCGCTACGACCGCTTCAAAGTTAAAACCCACGACGGCAAA
ACCGTTTCCTCCAACAACTTGAACCCGTCCTTCGGCGTTATCTGGCAACCGCACGAACACTGGT
CCTTCTCCGCCTCCCACAACTACGCCTCCCGCTCCCCGCGCTTGTACGACGCCTTGCAAACCCA
CGGCAAACGCGGCATCATCTCCATCGCCGACGGCACCAAAGCCGAACGCGCCCGCAACACCGA
AATCGGCTTCAACTACAACGACGGCACCTTCGCCGCCAACGGCTCCTACTTCTGGCAAACCATC
AAAGACGCCTTGGCCAACCCGCAAAACCGCCACGACTCCGTTGCCGTTCGCGAAGCCGTTAAC
GCCGGCTACATCAAAAACCACGGCTACGAATTGGGCGCCTCCTACCGCACCGGCGGCTTGACC
GCCAAAGTTGGCGTTTCCCACTCCAAACCGCGCTTCTACGACACCCACAAAGACAAATTGTTGT
CCGCCAACCCGGAATTCGGCGCCCAAGTTGGCCGCACCTGGACCGCCTCCTTGGCCTACCGCT
TCCAAAACCCGAACTTGGAAATCGGCTGGCGCGGCCGCTACGTTCAAAAAGCCGTTGGCTCCAT
CTTGGTTGCCGGCCAAAAAGACCGCAACGGCAAATTGGAAAACGTTGTTCGCAAAGGCTTCGGC
GTTAACGACGTTTTCGCCAACTGGAAACCGTTGGGCAAAGACACCTTGAACGTTAACTTGTCCGT
TAACAACGTTTTCAACACCTTCTACTACCCGCACTCCCAACGCTGGACCAACACCTTGCCGGGC
GTTGGCCGCGACGTTCGCTTGGGCGTTAACTACAAATTCTAA

FIG. 39

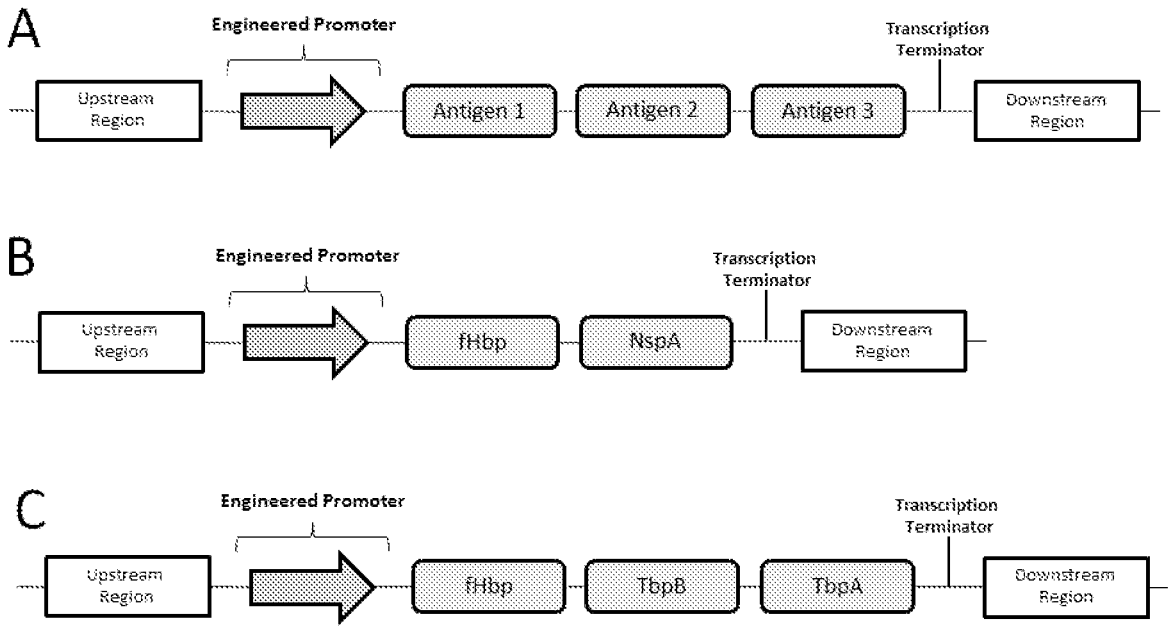
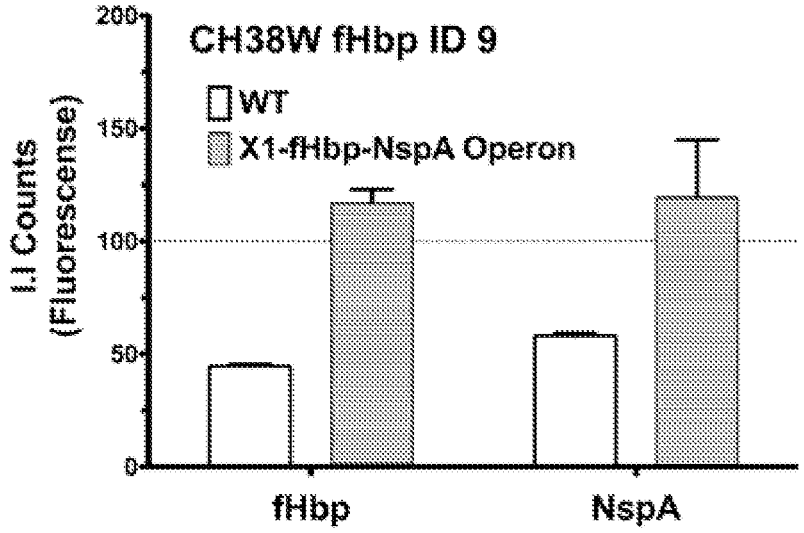

A
Engineered Promoter
Transcription Terminator
Upstream Region
Antigen 1
Antigen 2
Antigen 3
Downstream Region
B
Engineered Promoter
Transcription Terminator
Upstream Region
fHbp
NspA
Downstream Region
C
Engineered Promoter
Transcription Terminator
Upstream Region
fHbp
TbpB
TbpA
Downstream Region

FIG. 40


CH38W fHbp ID 9
WT
X1-fHbp-NspA Operon
I.I Counts (Fluorescense)
200
150
100
50
0
fHbp
NspA