ELECTRONIC SUPPLEMENTARY INFORMATION

Analytical data

Sodium 1,3-thiazolidine-4-carboxylate (a). 20.8 g, 84 %. mp. >250ºC dec. [α]D -150.8 (c 0.08 H_2O). ^{1}H NMR (400 MHz, d_2O) δ 2.65 (1H, dd, *J* = 10.7, 8.0 Hz SCH_2CH), 3.06 (1H, dd, *J* = 10.7, 7,1 Hz, SCH_2CH), 3.51 – 3.59 (1H, m, SCH$_2$C*H*), 3.82 (1H, d, *J* = 9.7 Hz, SCH_2N), 4.14 (1H, d, *J* = 9.7 Hz, SCH_2N). ^{13}C NMR (101 MHz, d_2O) δ 36.40 (S*C*H$_2$CH), 52.56 (S*C*H$_2$N) 67.39 (CH$_2$*C*HN), 177.99 (COO$^-$). IR (ATR) ν_{max}/cm^{-1}1588 and 1401 vs (COO$^-$).

Sodium 2-gluco-1,3-thiazolidine-4-carboxylate (b). 41.8 g, 79 %. mp. 145-148ºC. [α]D -91.2 (c 0.08 H_2O). ^{1}H NMR (400 MHz, d_2O) 2.53 (1H, t, *J* = 6.9 Hz, SCH_2CH), 2.75 (1H, dd, *J* = 10.5, 6.4 Hz, SCH_2CH), 2.98 (1H, dd, *J* = 10.5, 6.6 Hz, SCH_2CH), 3.10 (1H, dd, *J* = 10.3, 6.7 Hz, SCH_2CH), 3.38 – 3.50 (6H, m, C$H_{side\ chain}$), 3.53 – 3.60 (4H, m, C$H_{side\ chain}$), 3.66 (1H, dd, *J* = 5.5, 2.2 Hz, CH$_2$C*H*N), 3.70 – 3,72 (2H, dd, *J* = 5.7, 1.9 Hz, CHCH_2OH), 3.76 (1H, m, CH$_2$C*H*N), 4.50 (1H, d, *J* = 4.2 Hz, SCH_βN), 4.67 (1H, d, *J* = 5.5 Hz, SCH_αN). ^{13}C NMR (101 MHz, d_2O) δ 37.12 (2x S*C*H$_2$CH), 62.56, 62.64 (CH*C*H$_2$OH), 66.39, 67.95 (CH$_2$*C*HN), 69.32, 69.83 (S*C*H$_{\alpha\beta}$N), 70.74, 70.81, 70.83, 71.05, 71.12, 72.40, 73.87 (*C*H$_{side\ chain}$), 177.46, 178.14. IR (ATR) ν_{max}/cm^{-1} 3244 br (OH) 1587 and 1396 vs (COO$^-$).

Sodium 2-manno-1,3-thiazolidine-4-carboxylate (c). 41.9g, 79%. mp. 135-139ºC. [α]D -74.4 (c 0.08 H_2O). ^{1}H NMR (400 MHz, d_2O) δ 2.55 (1H, t, *J* = 10.2 Hz SCH_2CH), 2.85 (1H, dd, *J* = 10.4, 5.8 Hz, SCH_2CH), 3.08 (1H, dd, *J* = 10.5, 6.7 Hz, SCH_2CH), 3.16 (1H, dd, *J* = 10.3, 6.5 Hz, SCH_2CH), 3.48 – 3.58 (6H, m, C$H_{side\ chain}$), 3.61 – 3.68 (4H, m, C$H_{side\ chain}$), 3.71 (2H, m, CHCH_2OH) 3.81 (1H, dd, J = 8.6, 0.8 Hz, CH$_2$C*H*N), 3.93 (1H, dd, *J* = 7.2, 3.6 Hz, CH$_2$C*H*N), 4.73 (1H, d, *J* = 2.3 Hz, SCH_βN), 4.90 (1H, *J* = 3.1 Hz SCH_αN). ^{13}C NMR (101 MHz, d_2O) δ 36.91, 37.13 (S*C*H$_2$CH), 63.04 (2x CH*C*H$_2$OH), 67.06, 67.34 (CH$_2$*C*HN), 68.02, 68.84 (S*C*H$_{\alpha\beta}$N), 69.28, 69.48, 69.67, 70.41, 70.60, 70.80, 71.98, 72.03 (*C*H$_{side\ chain}$), 177.39, 178.50 (COO$^-$). IR (ATR) ν_{max}/cm^{-1} 3259 br (OH) 1586 and 1398 vs (COO$^-$).

Sodium 2-galacto-1,3-thiazolidine-4-carboxylate (d). 43.5 g, 80 %. mp. 145-148ºC. [α]D -79.4 (c 0.08 H_2O). [1]H NMR (400 MHz, d_2O) δ 2.70 (1H, t, J = 9.9 Hz, SCH_2CH), 2.78 (1H, dd, J = 10.5, 7.1 Hz, SCH_2CH), 3.08 (1H, dd, J = 10.5, 6.6 Hz, SCH_2CH), 3.18 (1H, dd, J = 10.4, 6.8 Hz, SCH_2CH), 3.57 – 3.61 (2H, m, $CH_{\alpha\beta}$CHCH), 3.47 – 3.56 (6H, m, C$H_{\text{side chain}}$), 3.63 (1H, dd, J = 8.2, 1.3 Hz, CH_2CHN), 3.73 (2H, m, CHCH_2OH), 3.82 (2H, m, CHCH_2OH), 3.86 (1H, dd, J = 7.8, 0.8 Hz, CH_2CHN), 4.52 (1H, d, J = 7.8 Hz , SCH_βN), 4.73 (1H, d, J = 8.3 Hz, SCH_αN). [13]C NMR (101 MHz, d_2O) δ 36.76 (2x S*C*H_2CH), 63.04, 63.07 (CH*C*H_2OH), 66.42, 67.69 (CH_2*C*HN), 69.22, 69.36 (S*C*$H_{\alpha\beta}$N), 69.56, 69.84, 69.98, 70.44, 70.74, 71.38, 71.76, 72.08 (*C*$H_{\text{side chain}}$), 177.33, 177.98 (COO^-). IR (ATR) ν_{max}/cm^{-1} 3241 br (OH) 1585 and 1396 vs (COO^-).

Sodium 2-arabino-1,3-thiazolidine-4-carboxylate (e). 42.9 g, 82 %. mp. 138-142ºC. [α]D -102.1 (c 0.08 H_2O). [1]H NMR (400 MHz, d2O) δ 2.52 (1H, t, J = 10.1 Hz , SCH_2CH), 2.62 (1H, dd, J = 10.3, 8.6 Hz, SCH_2CH), 3.07 (2H, ddd, J = 10.5, 6.6, 4.1 Hz, SCH_2CH), 3.38-3.45 (4H, m, CH_2CHN ,C$H_{\text{side chain}}$), 3.48 – 3.55 (2H, m, C$H_{\text{side chain}}$), 3.59 (2H, dt, J = 5.5, 2.6 Hz, CHCH_2OH) 3.63 (1H, dd, J = 3.7, 2.6 Hz, CH_2CHN), 3.92 (1H, dd, J = 4.9, 2.5 Hz, CHC*H*OHCHOH), 4.43 (1H, d, J = 5.0 Hz, SCH_βN), 4.60 (1H, d, J = 8.6 Hz, SCH_αN). [13]C NMR (101 MHz, d2O) δ 36.83, 37.32 (S*C*H_2CH), 62.61, 62.88 (CH*C*H_2OH), 65.80, 66.89 (CH_2*C*HN), 69.47, 70.39 (S*C*$H_{\alpha\beta}$N), 70.53, 70.75, 70.86, 70.86, 71.16, 71.66, 71.78 (*C*$H_{\text{side chain}}$), 177.46, 177.93 (COO^-). IR (ATR) ν_{max}/cm^{-1} 3245 br (OH) 1586 and 1397 vs (COO^-).

Sodium 2-ribo-1,3-thiazolidine-4-carboxylate (f). 42.3 g, 81 %. mp. 140-144ºC. [α]D -107.8 (c 0.06 H_2O). [1]H NMR (400 MHz, d2O) δ 2.68 (1H, dd, J = 10.7, 9.0 Hz, SCH_2CH), 2.80 (1H, dd, J = 10.7, 6.6 Hz, SCH_2CH), 3.02 (1H, dd, J = 10.7, 6.7 Hz, SCH_2CH), 3.11 (1H, dd, J = 10.7, 6.8 Hz, SCH_2CH), 3.38 – 3.48 (2H, m, C$H_{\text{side chain}}$), 3.52 – 3.63 (4H, m, C$H_{\text{side chain}}$), 3.64 –3.73 (4H, m, CH_2CHN, C$H_{\text{side chain}}$), 3.74 – 3.81 (1H, m, CHC*H*OHCHOH), 3.90 (1H, t, J = 6.5 Hz, CH_2CHN), 4.65 (1H, d, J = 3.2 Hz, SCH_βN), 4.82 (1H, d, J = 4.3 Hz SCH_αN). [13]C NMR (101 MHz, d2O) δ 35.98, 36.35 (S*C*H_2CH), 61.82, 61.88 (CH*C*H_2OH), 66.06, 66.94 (CH_2*C*HN), 68.91, 69.47 (S*C*$H_{\alpha\beta}$N), 70.70, 71.68, 72.16, 72.36, 72.49, 73.87 (*C*H $_{\text{side chain}}$), 176.37, 176.63 (COO^-). IR (ATR) ν_{max}/cm^{-1} 3253 br (OH) 1586 and 1396 vs (COO^-).

Sodium 2-xylo-1,3-thiazolidine-4-carboxylate (g). 42.7 g, 82 %. mp. 135-138ºC. [α]D -110.6 (c 0.08 H_2O). ^{1}H NMR (400 MHz, d2O) δ 2.64 (1H, t, *J* = 9.9 Hz, SCH_2CH), 2.75 (1H, dd, *J* = 10.6, 6.7 Hz, SCH_2CH), 3.01 (1H, dd, *J* = 10.6, 6.6 Hz, SCH_2CH), 3.11 (1H, dd, *J* = 10.5, 6.8 Hz SCH_2CH), 3.36 – 3.46 (1H, m, $CH_{\text{side chain}}$), 3.47 – 3.55 (5H, m, CH_2CHN, $CH_{\text{side chain}}$), 3.57- 3.63 (4H, m, $CHCH_2OH$, $CH_{\text{side chain}}$), 3.71 (1H, t, *J* = 4.8 Hz, $CHCH_2OH$), 3.75 (1H, t, *J* = 6.6 Hz, CH_2CHN), 4.52 (1H, d, *J* = 5.2 Hz, $SCH_{\beta}N$), 4.69 (1H, d, *J* = 6.0 Hz, $SCH_{\alpha}N$). ^{13}C NMR (101 MHz, d2O) δ 36.74, 36.79 (SCH_2CH), 62.27, 62.36 ($CHCH_2OH$), 66.32, 67.65 (CH_2CHN), 69.38, 69.87 ($SCH_{\alpha\beta}N$), 71.65, 71.74, 71.92, 71.97, 72.18, 73.14 ($CH_{\text{side chain}}$), 176.99, 177.73 (COO^-). IR (ATR) ν_{max}/cm^{-1} 3242 br (OH) 1585 and 1396 vs (COO^-).

Effect of the spray-drying operating conditions on the outlet air temperature (Toutlet) and on the yield (Np), moisture content, bulk density (BD), and solubility of the product.

Entry	*Qa* (%)	T_{inlet} (°C)	Feed flow (mL/min)	T_{outlet} (°C)	N_p (%)	Moisture (%)[a]	BD (g/mL)[b]	Solubility rate (s)[a]
a	90	125	3	48	70.5	1.03 ± 0.02	0.27	98 ± 3
			4.5	45	65.4	1.28 ± 0.04	0.29	110 ± 3
			6	41	50.3	1.56 ± 0.03	0.31	123 ± 5
		140	3	52	77.5	0.92 ± 0.01	0.25	94 ± 4
			4.5	47	76.3	1.20 ± 0.03	0.27	103 ± 3
			6	43	73.6	1.47 ± 0.02	0.29	115 ± 4
		160	3	60	83.9	0.72 ± 0.03	0.23	85 ± 3
			4.5	54	78.1	0.99 ± 0.02	0.26	92 ± 4
			6	47	75.3	1.06 ± 0.01	0.26	94 ± 3
b	90	125	3	47	29.5	1.10 ± 0.04	0.30	201 ± 4
			4.5	45	17.3	1.25 ± 0.05	0.31	214 ± 3
			6	42	7.8	1.47 ± 0.05	0.32	219 ± 4
		140	3	61	63.6	0.88 ± 0.04	0.26	192 ± 4
			4.5	60	61.3	1.12 ± 0.04	0.29	211 ± 4
			6	58	23.4	1.35 ± 0.04	0.32	217 ± 3
		160	3	85	79.5	0.77 ± 0.02	0.25	185 ± 3
			4.5	82	68.6	1.00 ± 0.04	0.28	200 ± 5
			6	80	35.8	1.09 ± 0.04	0.29	207 ± 4
c	90	125	3	53	67.4	1.19 ± 0.02	0.30	206 ± 5
			4.5	48	41.3	1.32 ± 0.04	0.33	218 ± 4
			6	45	22.8	1.53 ± 0.04	0.35	227 ± 4
		140	3	58	74.1	1.01 ± 0.05	0.28	198 ± 4

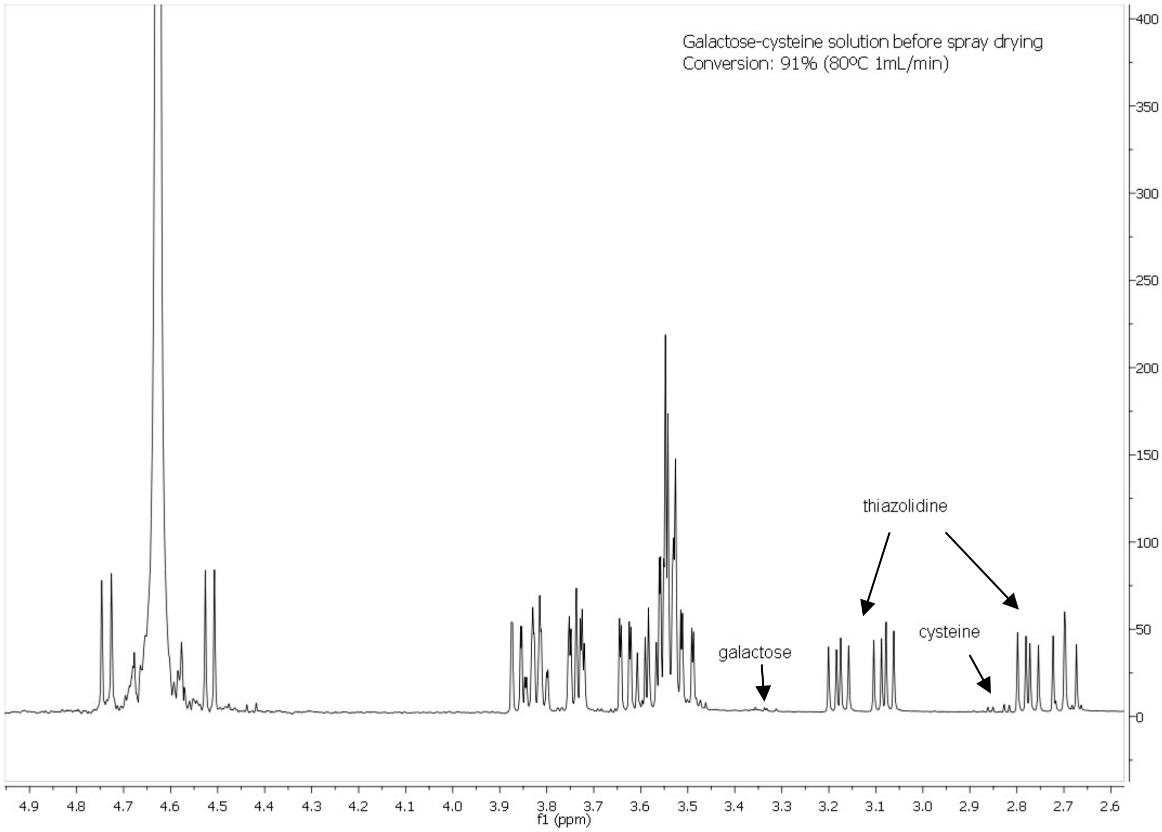
			4.5	50	42.9	1.17 ± 0.05	0.29	206 ± 4
			6	47	29.5	1.29 ± 0.03	0.30	217 ± 5
		160	3	56	79.1	0.80 ± 0.04	0.25	189 ± 3
			4.5	52	69.6	0.90 ± 0.01	0.27	192 ± 3
			6	50	43.5	0.99 ± 0.02	0.27	197 ± 4
d	90	125	3	50	47.9	1.01 ± 0.03	0.26	192 ± 3
			4.5	46	36.4	1.27 ± 0.03	0.29	202 ± 5
			6	44	15.7	1.48 ± 0.05	0.31	218 ± 3
		140	3	61	59.2	0.82 ± 0.021	0.25	184 ± 5
			4.5	54	39.9	1.04 ± 0.03	0.26	191 ± 3
			6	53	19.8	1.27 ± 0.04	0.28	203 ± 3
		160	3	66	82.2	0.68 ± 0.02	0.23	179 ± 3
			4.5	64	74.1	0.84 ± 0.03	0.24	186 ± 4
			6	57	35.7	1.02 ± 0.04	0.25	193 ± 3
e	75	125	3	59	67.1	0.92 ± 0.03	0.30	182 ± 4
			4.5	54	48.5	0.99 ± 0.04	0.30	189 ± 3
			6	51	19.8	1.11 ± 0.04	0.31	210 ± 4
		140	3	67	65.8	0.81 ± 0.053	0.29	176 ± 3
			4.5	58	57.1	0.93 ± 0.02	0.30	184 ± 2
			6	53	26.0	1.10 ± 0.03	0.31	203 ± 4
		160	3	69	81.8	0.58 ± 0.04	0.26	159 ± 4
			4.5	64	60.4	0.76 ± 0.02	0.28	171 ± 3
			6	62	43.6	0.96 ± 0.03	0.29	180 ± 5
f	75	125	3	60	74.4	0.91 ± 0.03	0.29	187 ± 5
			4.5	56	48.2	1.17 ± 0.04	0.31	205 ± 3
			6	52	11.6	1.27 ± 0.04	0.33	215 ± 3
		140	3	64	75.6	0.78 ± 0.04	0.28	175 ± 4
			4.5	58	40.7	1.11 ± 0.03	0.30	199 ± 5
			6	54	18.5	1.19 ± 0.05	0.31	207 ± 2
		160	3	68	80.8	0.71 ± 0.03	0.28	161 ± 4
			4.5	63	63.9	0.77 ± 0.04	0.28	164 ± 4
			6	62	38.4	0.83 ± 0.04	0.29	172 ± 3
g	75	125	3	61	63.2	0.89 ± 0.05	0.29	179 ± 3
			4.5	57	46.7	1.16 ± 0.03	0.31	196 ± 4
			6	53	20.4	1.30 ± 0.03	0.32	208 ± 5
		140	3	65	65.4	1.00 ± 0.04	0.30	168 ± 4
			4.5	61	50.9	1,11 ± 0.03	0.31	184 ± 4
			6	57	23.1	1.20 ± 0.04	0.32	199 ± 3
		160	3	67	81.6	0.53 ± 0.03	0.28	152 ± 5
			4.5	65	64.7	0.69 ± 0.02	0.28	160 ± 3
			6	62	53.3	0.97 ± 0.03	0.30	168 ± 3
g	90	125	3	64	32.6	1.07 ±0.04	0.30	187 ± 2
			4.5	60	25.9	1.30 ± 0.04	0.32	206 ± 3
			6	57	10.8	1.52 ± 0.03	0.35	218 ± 4
		140	3	68	40.2	0.94 ± 0.05	0.30	171 ± 4
			4.5	64	31.5	1.18 ± 0.04	0.32	198 ± 4
			6	61	19.8	1.29 ± 0.04	0.33	210 ± 5
		160	3	70	48.1	0.85 ± 0.03	0.29	167 ± 3

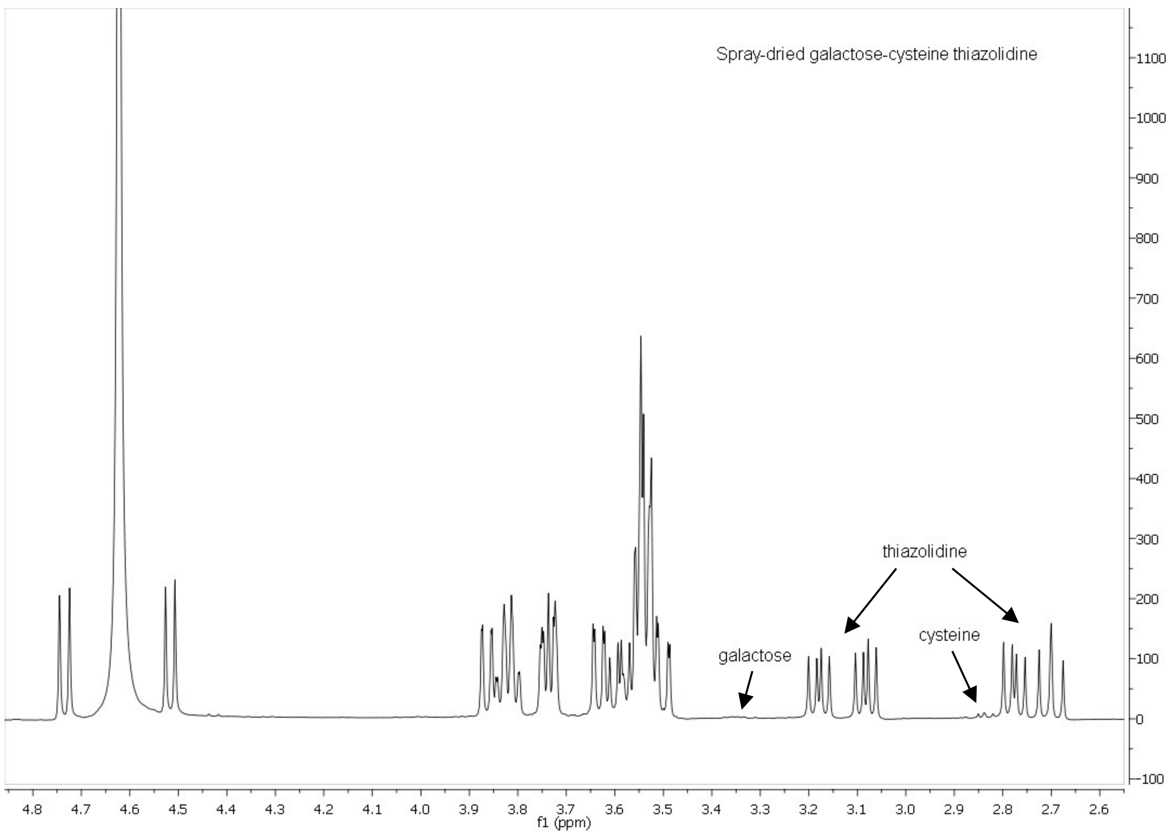
			4.5	68	30.2	1.00 ± 0.04	0.30	172 ± 3
			6	64	24.6	1.13 ± 0.03	0.31	191 ± 3
b, c	75	160	3	74	74.9	0.80 ± 0.02	0.29	183 ± 3
d, b, c	75	160	3	72	81.9	0.93 ± 0.03	0.28	181 ± 4
e, d	75	160	3	74	78.2	0.94 ± 0.02	0.28	174 ± 4
g,e	75	160	3	75	77.4	0.60 ± 0.05	0.29	168 ± 3

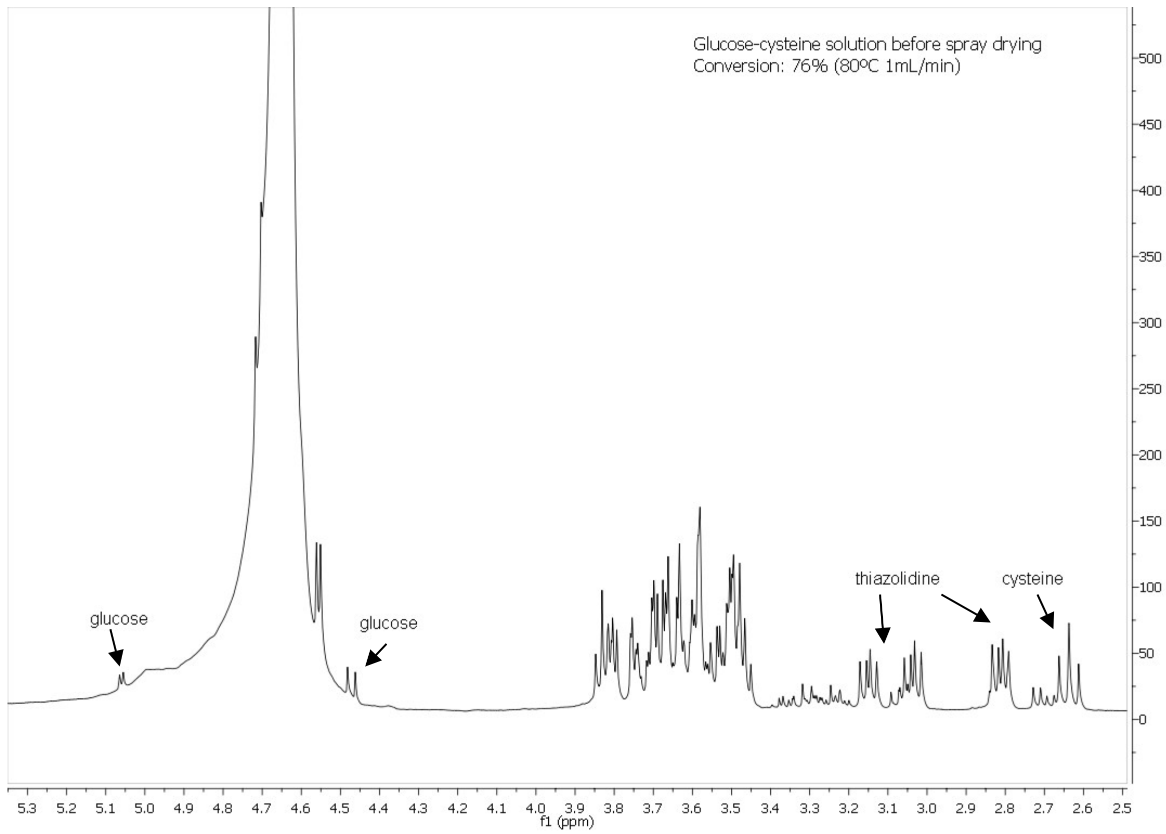
Table of percentage of conversion in batch system

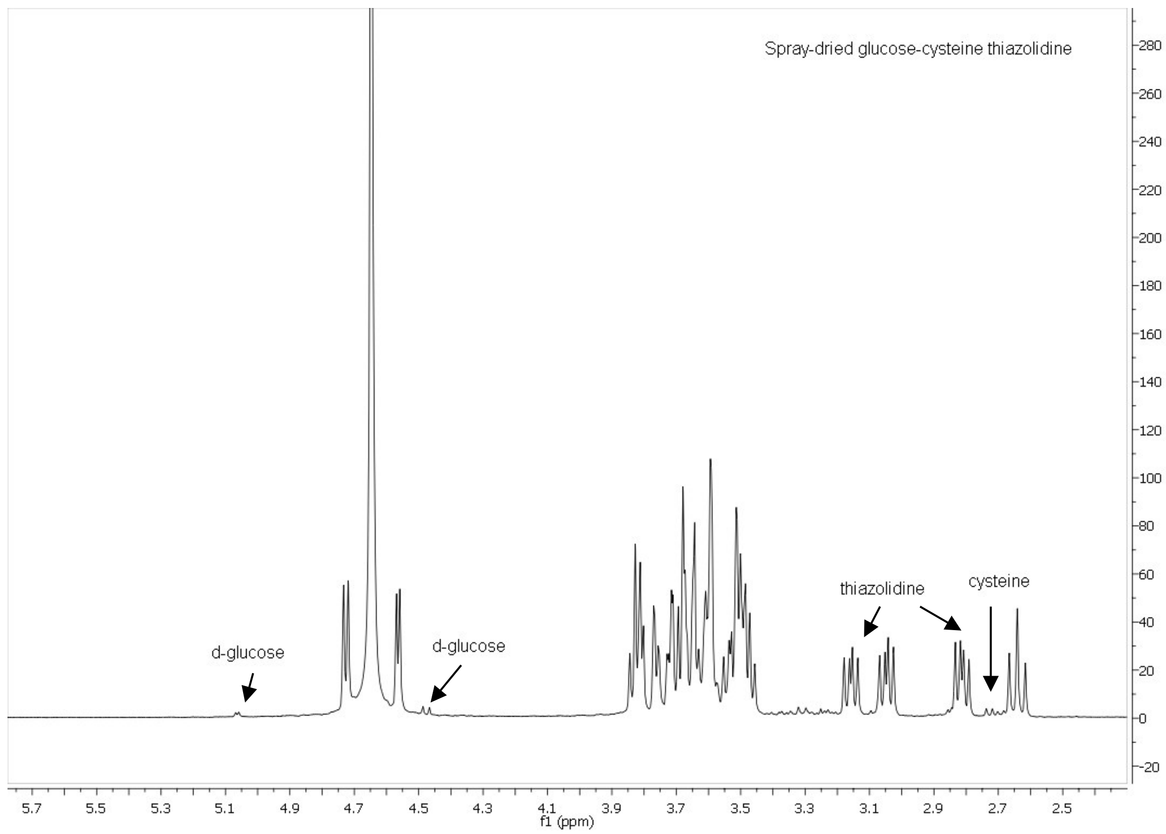
Time (min)	8	45	75	240
D-glucose	48.8	64.6	70.8	77.2
D-galactose	61.2	78.3	85.2	87.2
D-mannose	55.32	74.2	83.7	93
D-xylose	70	82	94.1	93.9
D-ribose	71.1	85.7	92	91.4
D-arabinose	65.4	86.6	85.5	85.6

[1]H-NMR spectra of D-galactose and D-glucose derivatives of sodium 1,3-thiazolidine-4-carboxylates before and after spray drying.






Glucose-cysteine solution before spray drying
Conversion: 76% (80ºC 1mL/min)
glucose
glucose
thiazolidine
cysteine
f1 (ppm)


Spray-dried glucose-cysteine thiazolidine
d-glucose
d-glucose
thiazolidine
cysteine
f1 (ppm)