Protein Concentrate Production from Thin Stillage

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SUPPORTING INFORMATION

Table S1. Mass balance of clarification of replications of small-scale TSF replicate 2.

Table S2. Protein and moisture contents of wash fractions from pilot-scale processing replicate 2.

Figure S1. Moisture and protein contents: (A) moisture content of fermenter 1 wash fractions, (B) protein content of fermenter 1 wash fractions, (C) moisture content of fermenter 1 wash fractions, and (D) protein content of fermenter 2 wash fractions after washing slurry I from fermentation at 25 °C (replicate 2). Each value is presented as the mean ± standard deviation (SD, n = 2). Total nitrogen was determined by the Kjeldahl method. Corrected protein was calculated using conversion factor of 5.7 times N and expressed as crude protein. Nitrogen in the samples contributed by GPC and betaine was determined by DPFGSE-NMR. Nitrogen contributed by these materials to total nitrogen was subtracted prior to calculation of protein content.

Figure S2. Concentration (g/L) of organic solutes of liquid fractions from washing slurry I after fermentation at 25 °C of (A) fermenter 1 and (B) fermenter 2 replicate 2. The concentration of glycerol in the samples may be affected by the presence of interfering resonances from carbohydrate and protein

Figure S3. Concentration (g/L) of 1,3-PD, acetic acid, glycerol, GPC, and lactic acid from washing of replications of small-scale TSF of (A) slurry I, (B) liquid after decanting, and (C) liquid after desludging replicate 2.

Figure S4. Protein balance of pilot-scale processing replicate 1.

Figure S5. Glycerol balance of pilot-scale processing replicate 1.

Figure S6. 1,3-PD balance of pilot-scale processing replicate 1.

Figure S7. Lactic acid balance of pilot-scale processing replicate 1.

Figure S8. Acetic acid balance of pilot-scale processing replicate 1.

Figure S9. GPC balance of pilot-scale processing replicate 1.

Table S1. Mass Balance of Clarification of Replications of Small-scale TSF Replicate 2

sample	weight of sample (kg)
slurry I	227.23
liquid I	nd[a]
solid I decanter	74.45
solid I desludger	29.29
liquid I desludger	142.00
solid II decanter	60.47
solid II desludger	9.05
water added for1st wash	103.00
liquid II desludger	113.00
solid III decanter	63.30
solid III desludger	11.70
water added for 2nd wash	70.00
liquid III desludger	63.50

[a]nd = not determined.

Table S2. Protein and Moisture Contents[a] of Wash Fractions from Pilot-scale Processing Replicate 2

sample	moisture (%, w/w, wb)	protein[b] (%, w/w, wb)	protein (%, w/w, db)
slurry I[c]	90.26 ± 0.01	4.74 ± 0.02	48.68 ± 0.19
solid I decanter	81.04 ± 0.07	11.75 ± 0.04	62.00 ± 0.46
liquid I decanter[c]	96.75 ± 0.00	0.87 ± 0.02	26.75 ± 0.60
solid I desludger	92.87 ± 0.01	2.71 ± 0.00	38.02 ± 0.05
liquid I desludger[c]	97.18 ± 0.00	0.66 ± 0.01	23.43 ± 0.47
mixture of solid and water before 1st wash[c]	92.68 ± 0.01	4.16 ± 0.05	56.78 ± 0.69
solid II decanter	81.68 ± 0.03	11.41 ± 0.10	62.25 ± 0.64
liquid II decanter[c]	98.48 ± 0.00	0.47 ± 0.01	31.09 ± 0.84
solid II desludger	93.48 ± 0.00	2.87 ± 0.02	44.07 ± 0.34
liquid II desludger[c]	98.63 ± 0.02	0.32 ± 0.01	23.16 ± 0.54
mixture of solid and water before 2nd wash[c]	92.62 ± 0.00	4.53 ± 0.05	61.35 ± 0.65
solid III decanter	81.82 ± 0.00	11.60 ± 0.20	63.88 ± 1.05
liquid III decanter[c]	99.16 ± 0.00	0.30 ± 0.00	36.27 ± 0.45
solid III desludger	96.64 ± 0.00	1.65 ± 0.02	49.16 ± 0.06
liquid III desludger[c]	99.41 ± 0.02	0.18 ± 0.01	30.97 ± 2.46

[a]Each value is presented as the mean ± SD (n = 2). [b]Total nitrogen was determined by the Kjeldahl method. Corrected protein was calculated using conversion factor 5.7 as expressed as crude protein. [c]Nitrogen in the samples contributed by GPC and betaine was determined by DPFGSE-NMR. Nitrogen contributed by these materials to total nitrogen was subtracted prior to calculation of protein content.

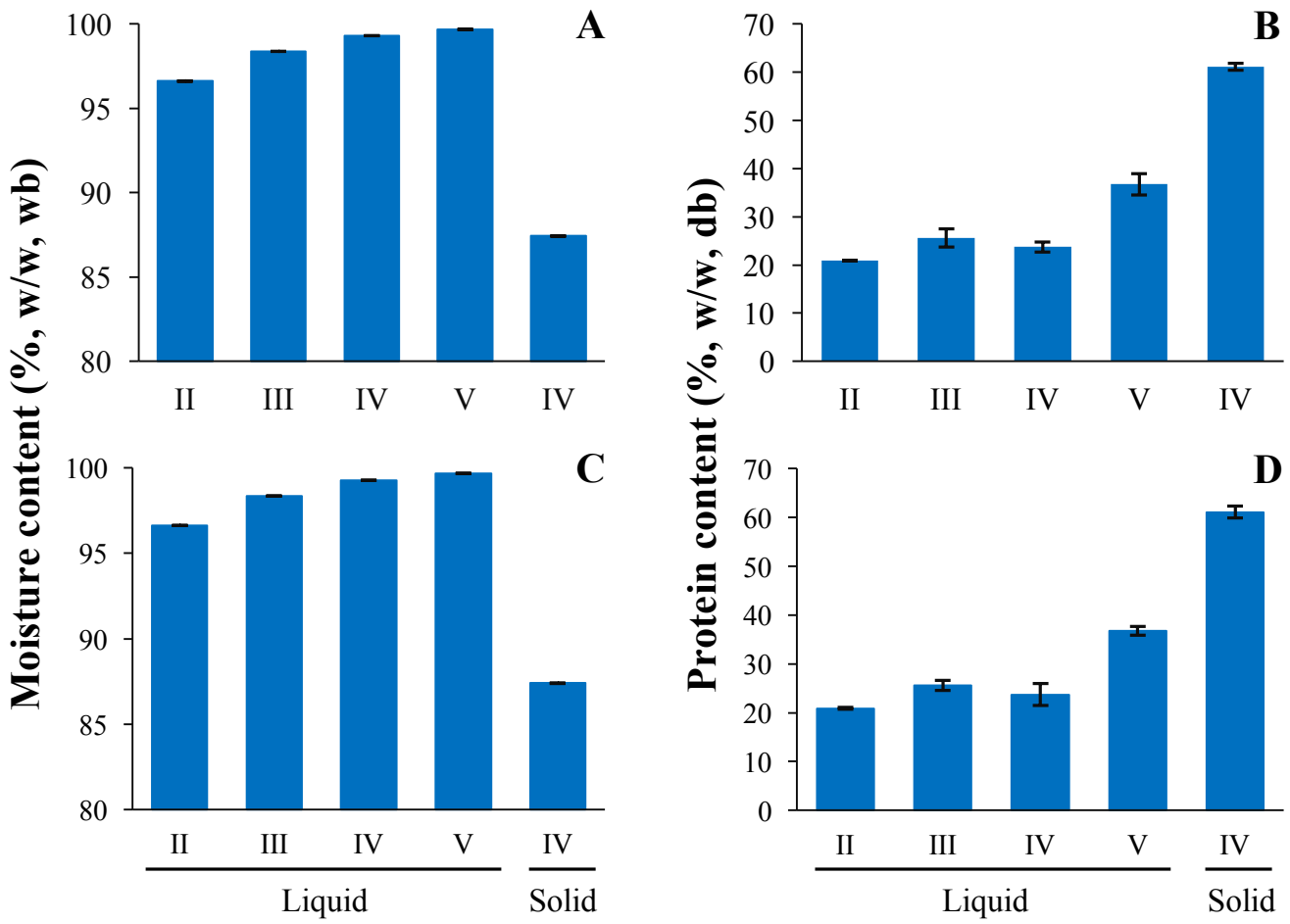
A
B
C
D
Moisture content (%, w/w, wb)
Protein content (%, w/w, db)
100
95
90
85
80
70
60
50
40
30
20
10
0
II
III
IV
V
IV
Liquid
Solid

Figure S1.

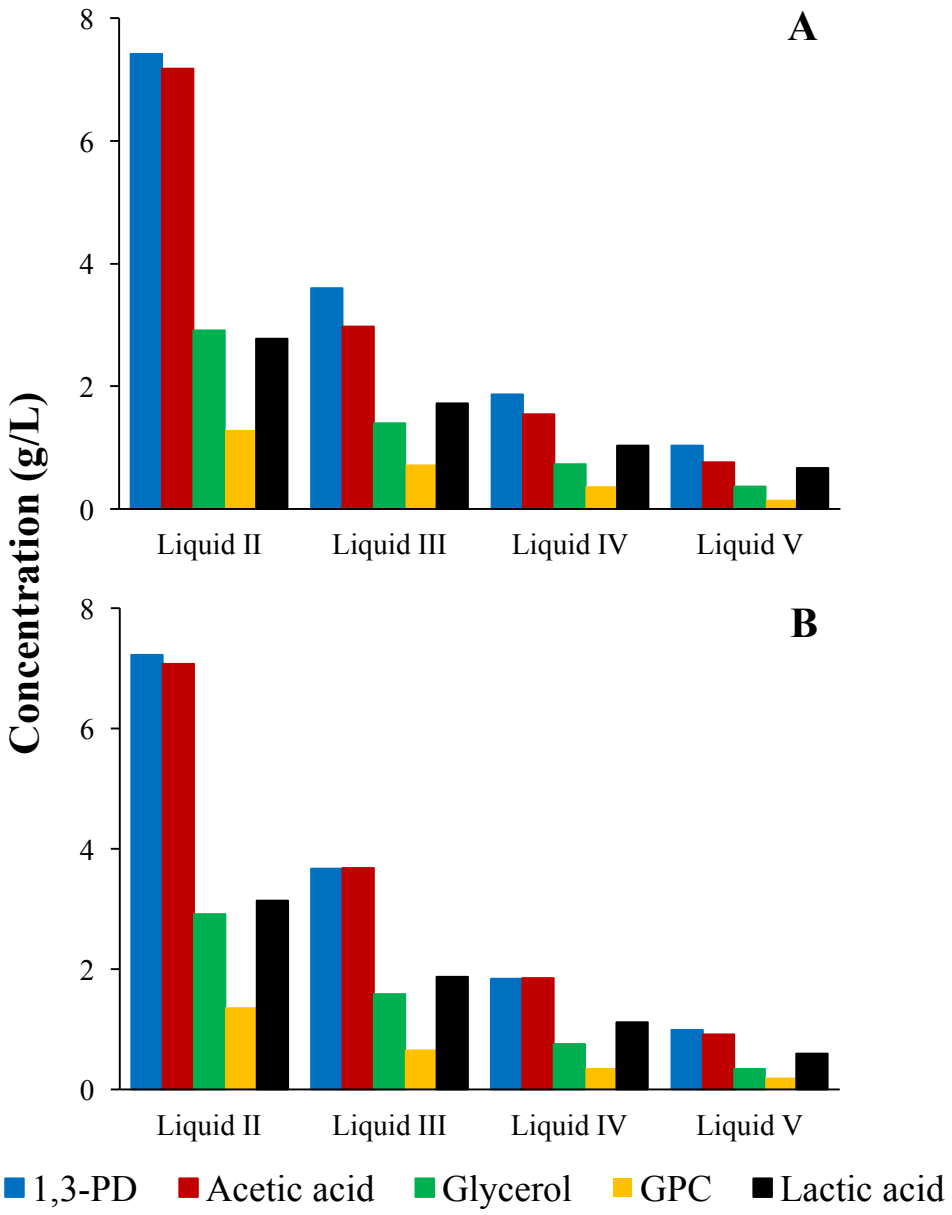
A
B
Concentration (g/L)
8
6
4
2
0
Liquid II
Liquid III
Liquid IV
Liquid V
1,3-PD
Acetic acid
Glycerol
GPC
Lactic acid

Figure S2.

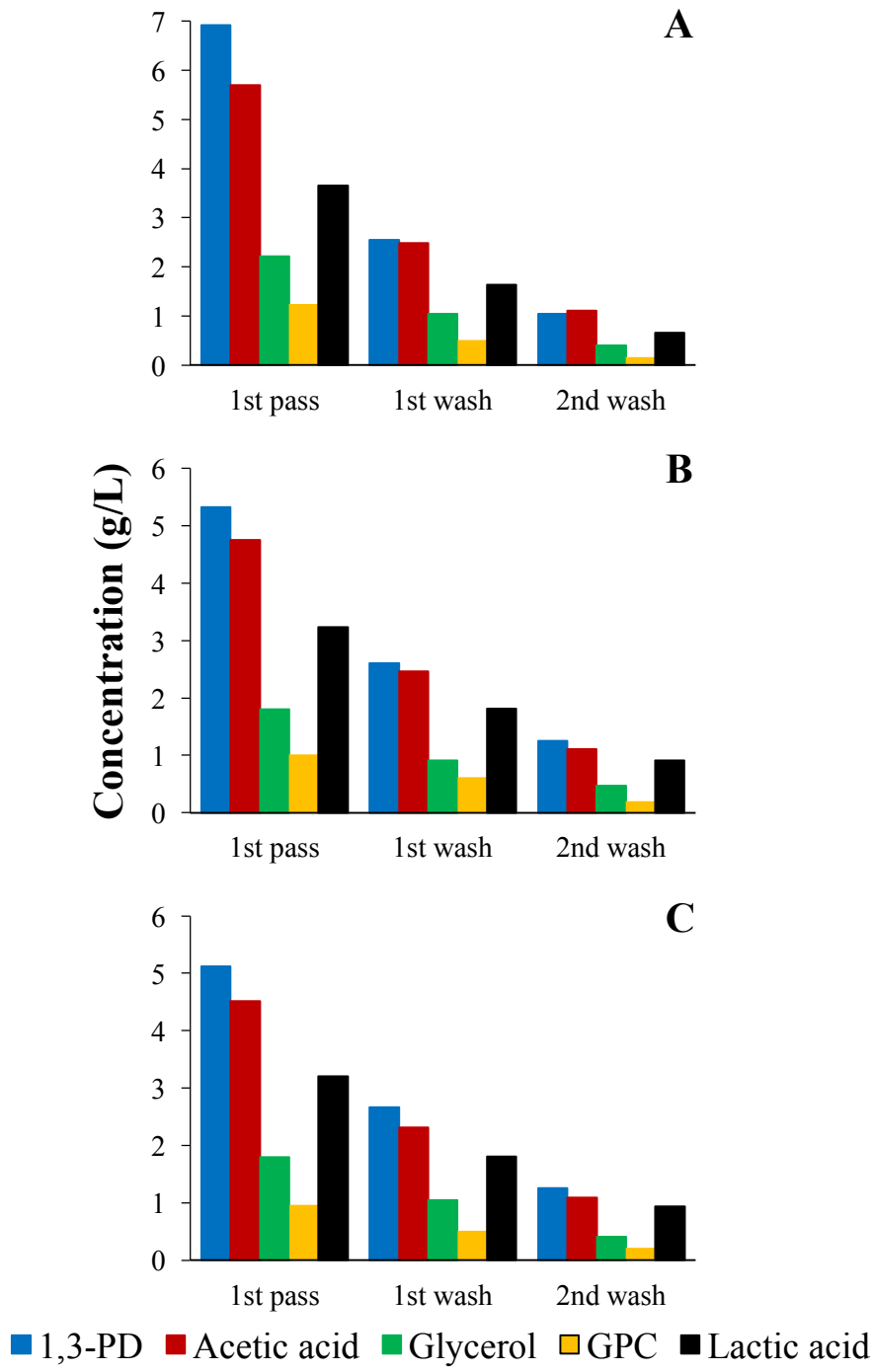
A
B
C
Concentration (g/L)
0
1
2
3
4
5
6
7
1st pass
1st wash
2nd wash
1,3-PD
Acetic acid
Glycerol
GPC
Lactic acid

Figure S3.

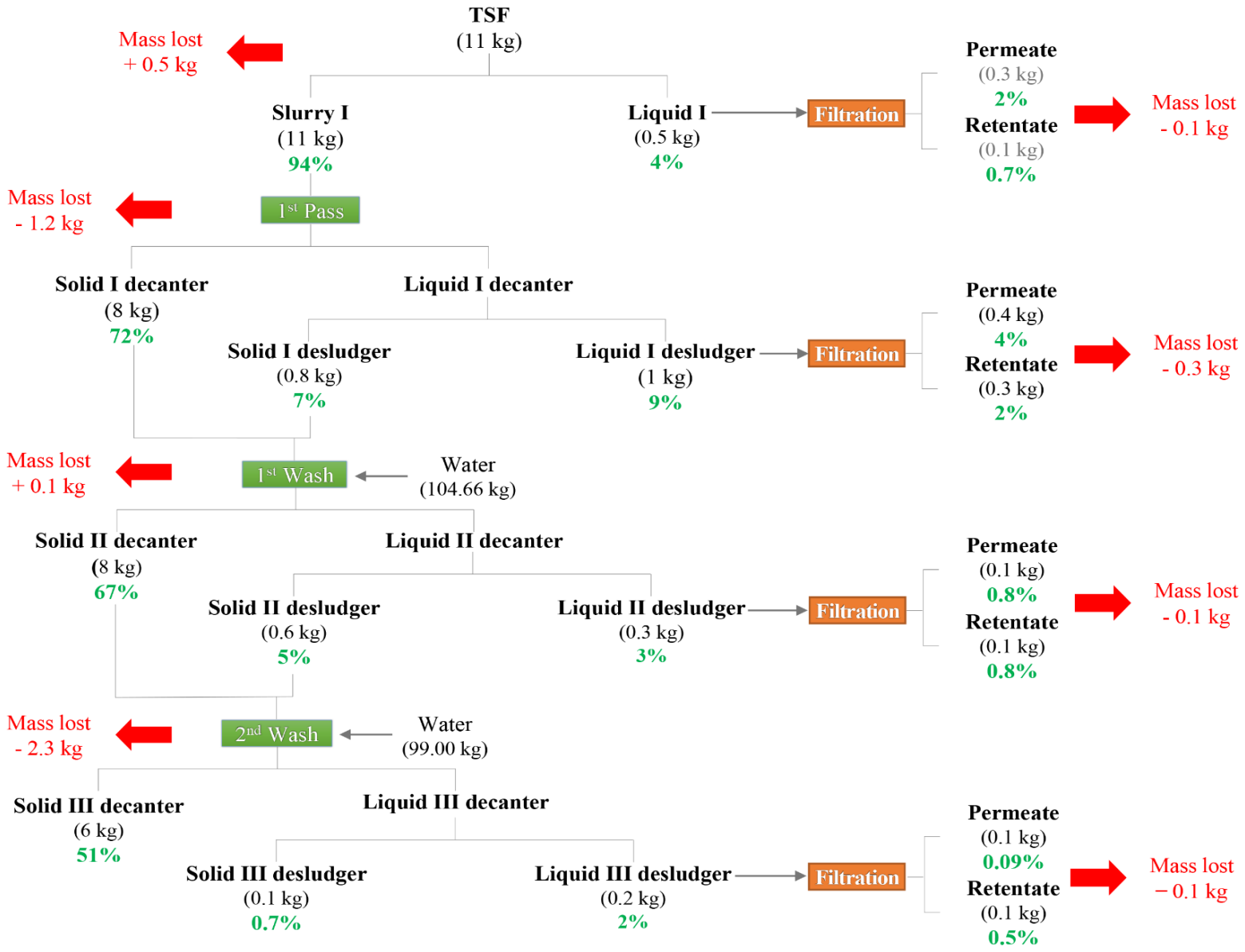
TSF
(11 kg)
Mass lost
+ 0.5 kg
Slurry I
(11 kg)
94%
Liquid I
(0.5 kg)
4%
Filtration
Permeate
(0.3 kg)
2%
Retentate
(0.1 kg)
0.7%
Mass lost
- 0.1 kg
Mass lost
- 1.2 kg
1st Pass
Solid I decanter
(8 kg)
72%
Liquid I decanter
Solid I desludger
(0.8 kg)
7%
Liquid I desludger
(1 kg)
9%
Filtration
Permeate
(0.4 kg)
4%
Retentate
(0.3 kg)
2%
Mass lost
- 0.3 kg
Mass lost
+ 0.1 kg
1st Wash
Water
(104.66 kg)
Solid II decanter
(8 kg)
67%
Liquid II decanter
Solid II desludger
(0.6 kg)
5%
Liquid II desludger
(0.3 kg)
3%
Filtration
Permeate
(0.1 kg)
0.8%
Retentate
(0.1 kg)
0.8%
Mass lost
- 0.1 kg
Mass lost
- 2.3 kg
2nd Wash
Water
(99.00 kg)
Solid III decanter
(6 kg)
51%
Liquid III decanter
Solid III desludger
(0.1 kg)
0.7%
Liquid III desludger
(0.2 kg)
2%
Filtration
Permeate
(0.1 kg)
0.09%
Retentate
(0.1 kg)
0.5%
Mass lost
− 0.1 kg

Figure S4.

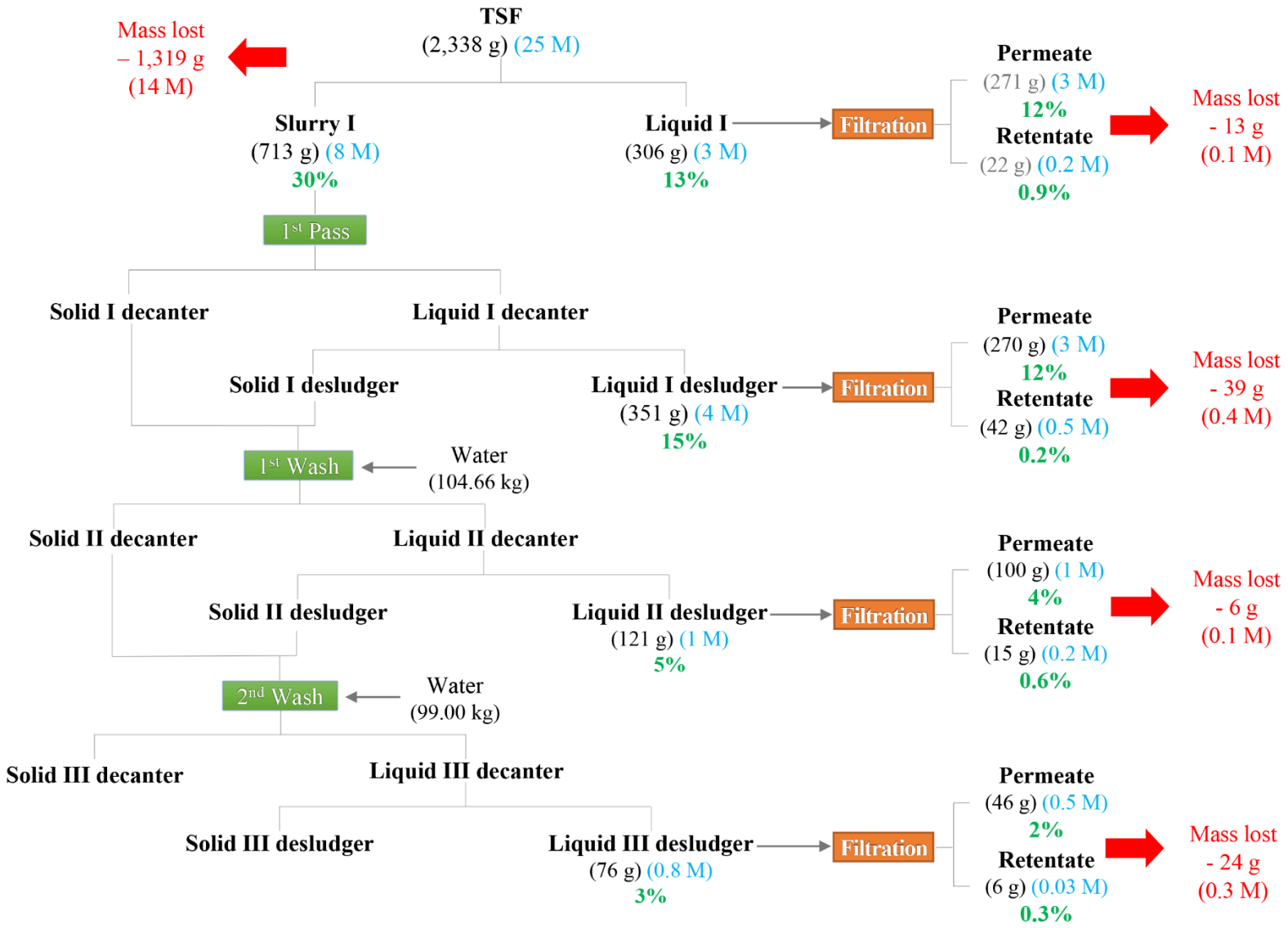
TSF
(2,338 g) (25 M)
Mass lost
– 1,319 g
(14 M)
Slurry I
(713 g) (8 M)
30%
Liquid I
(306 g) (3 M)
13%
Filtration
Permeate
(271 g) (3 M)
12%
Retentate
(22 g) (0.2 M)
0.9%
Mass lost
- 13 g
(0.1 M)
1st Pass
Solid I decanter
Liquid I decanter
Solid I desludger
Liquid I desludger
(351 g) (4 M)
15%
Filtration
Permeate
(270 g) (3 M)
12%
Retentate
(42 g) (0.5 M)
0.2%
Mass lost
- 39 g
(0.4 M)
1st Wash
Water
(104.66 kg)
Solid II decanter
Liquid II decanter
Solid II desludger
Liquid II desludger
(121 g) (1 M)
5%
Filtration
Permeate
(100 g) (1 M)
4%
Retentate
(15 g) (0.2 M)
0.6%
Mass lost
- 6 g
(0.1 M)
2nd Wash
Water
(99.00 kg)
Solid III decanter
Liquid III decanter
Solid III desludger
Liquid III desludger
(76 g) (0.8 M)
3%
Filtration
Permeate
(46 g) (0.5 M)
2%
Retentate
(6 g) (0.03 M)
0.3%
Mass lost
- 24 g
(0.3 M)

Figure S5.

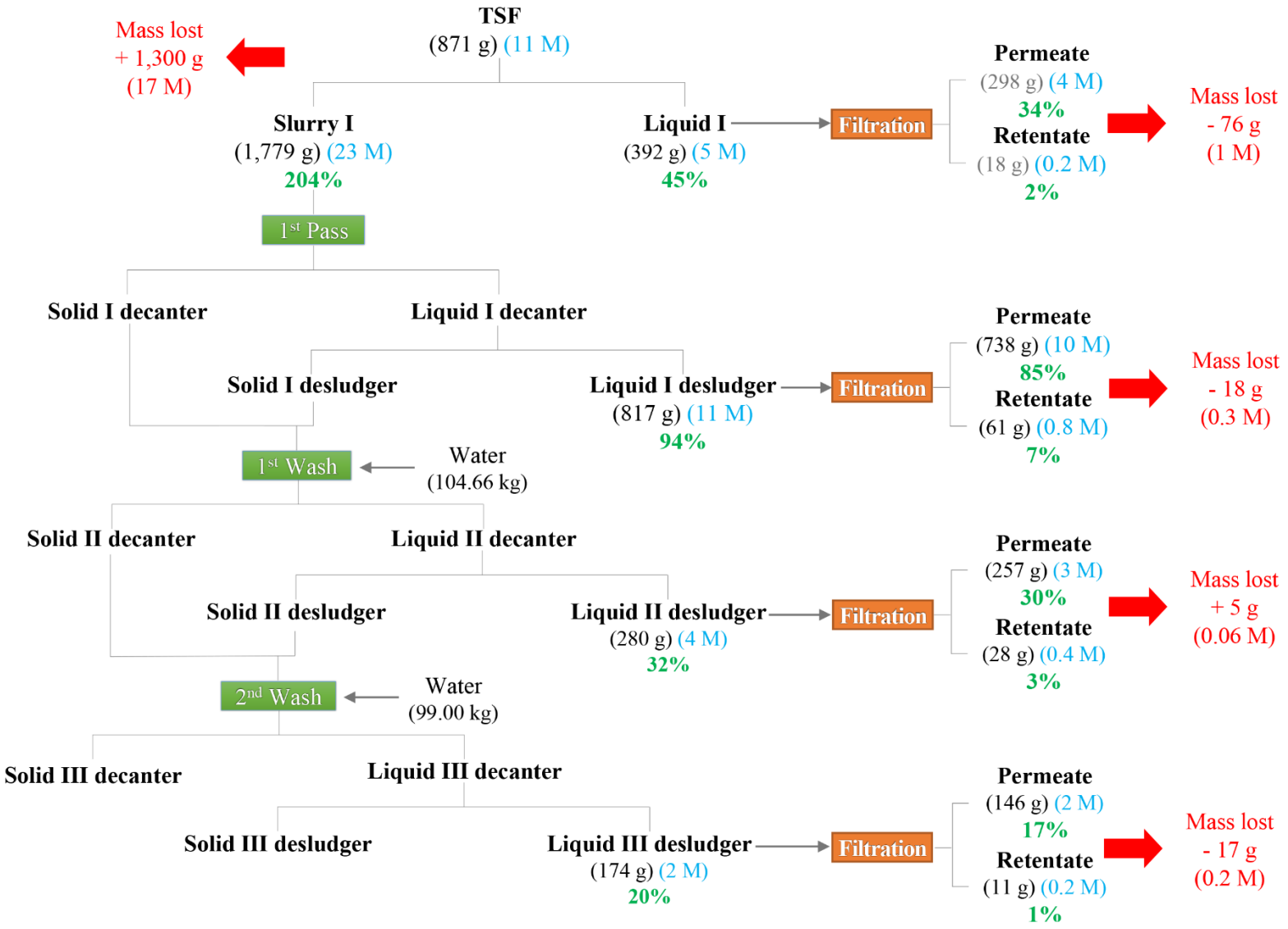
TSF
(871 g) (11 M)
Mass lost
+ 1,300 g
(17 M)
Slurry I
(1,779 g) (23 M)
204%
Liquid I
(392 g) (5 M)
45%
Filtration
Permeate
(298 g) (4 M)
34%
Retentate
(18 g) (0.2 M)
2%
Mass lost
- 76 g
(1 M)
1st Pass
Solid I decanter
Liquid I decanter
Solid I desludger
Liquid I desludger
(817 g) (11 M)
94%
Filtration
Permeate
(738 g) (10 M)
85%
Retentate
(61 g) (0.8 M)
7%
Mass lost
- 18 g
(0.3 M)
1st Wash
Water
(104.66 kg)
Solid II decanter
Liquid II decanter
Solid II desludger
Liquid II desludger
(280 g) (4 M)
32%
Filtration
Permeate
(257 g) (3 M)
30%
Retentate
(28 g) (0.4 M)
3%
Mass lost
+ 5 g
(0.06 M)
2nd Wash
Water
(99.00 kg)
Solid III decanter
Liquid III decanter
Solid III desludger
Liquid III desludger
(174 g) (2 M)
20%
Filtration
Permeate
(146 g) (2 M)
17%
Retentate
(11 g) (0.2 M)
1%
Mass lost
- 17 g
(0.2 M)

Figure S6.

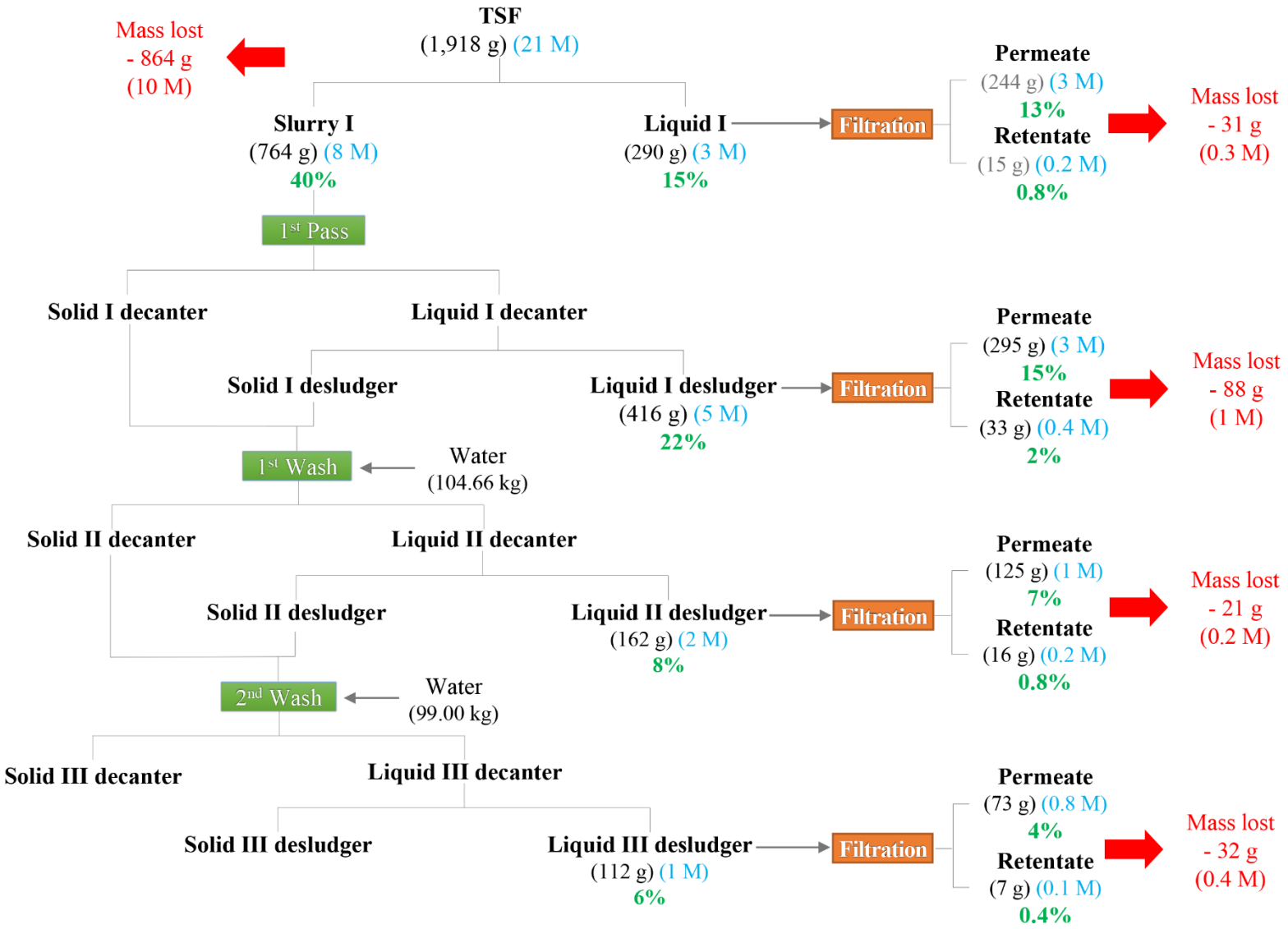
TSF
(1,918 g) (21 M)
Mass lost
- 864 g
(10 M)
Slurry I
(764 g) (8 M)
40%
Liquid I
(290 g) (3 M)
15%
Filtration
Permeate
(244 g) (3 M)
13%
Retentate
(15 g) (0.2 M)
0.8%
Mass lost
- 31 g
(0.3 M)
1st Pass
Solid I decanter
Liquid I decanter
Solid I desludger
Liquid I desludger
(416 g) (5 M)
22%
Filtration
Permeate
(295 g) (3 M)
15%
Retentate
(33 g) (0.4 M)
2%
Mass lost
- 88 g
(1 M)
1st Wash
Water
(104.66 kg)
Solid II decanter
Liquid II decanter
Solid II desludger
Liquid II desludger
(162 g) (2 M)
8%
Filtration
Permeate
(125 g) (1 M)
7%
Retentate
(16 g) (0.2 M)
0.8%
Mass lost
- 21 g
(0.2 M)
2nd Wash
Water
(99.00 kg)
Solid III decanter
Liquid III decanter
Solid III desludger
Liquid III desludger
(112 g) (1 M)
6%
Filtration
Permeate
(73 g) (0.8 M)
4%
Retentate
(7 g) (0.1 M)
0.4%
Mass lost
- 32 g
(0.4 M)

Figure S7.

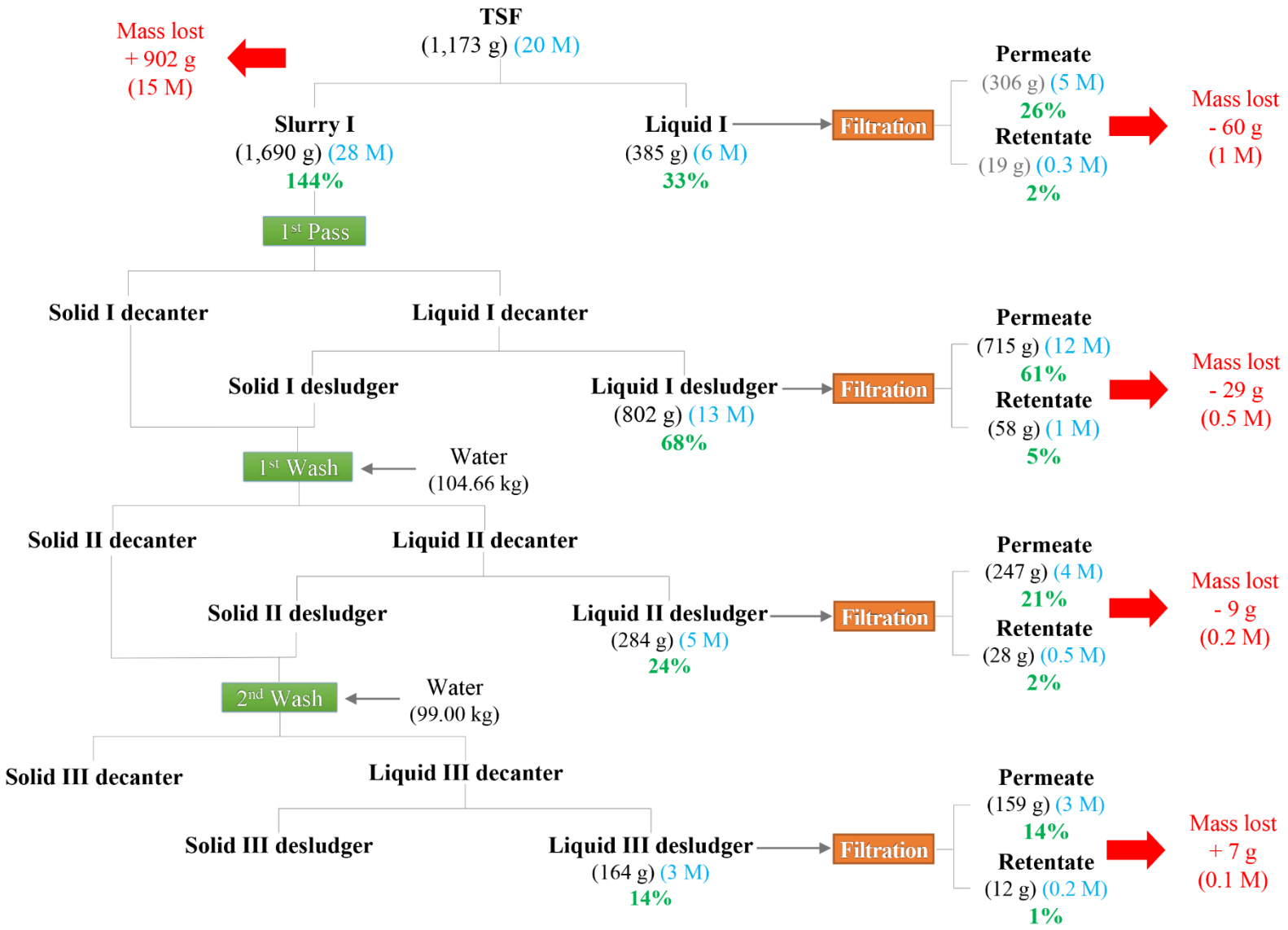
TSF
(1,173 g) (20 M)
Mass lost
+ 902 g
(15 M)
Slurry I
(1,690 g) (28 M)
144%
Liquid I
(385 g) (6 M)
33%
Filtration
Permeate
(306 g) (5 M)
26%
Retentate
(19 g) (0.3 M)
2%
Mass lost
- 60 g
(1 M)
1st Pass
Solid I decanter
Liquid I decanter
Solid I desludger
Liquid I desludger
(802 g) (13 M)
68%
Filtration
Permeate
(715 g) (12 M)
61%
Retentate
(58 g) (1 M)
5%
Mass lost
- 29 g
(0.5 M)
1st Wash
Water
(104.66 kg)
Solid II decanter
Liquid II decanter
Solid II desludger
Liquid II desludger
(284 g) (5 M)
24%
Filtration
Permeate
(247 g) (4 M)
21%
Retentate
(28 g) (0.5 M)
2%
Mass lost
- 9 g
(0.2 M)
2nd Wash
Water
(99.00 kg)
Solid III decanter
Liquid III decanter
Solid III desludger
Liquid III desludger
(164 g) (3 M)
14%
Filtration
Permeate
(159 g) (3 M)
14%
Retentate
(12 g) (0.2 M)
1%
Mass lost
+ 7 g
(0.1 M)

Figure S8.

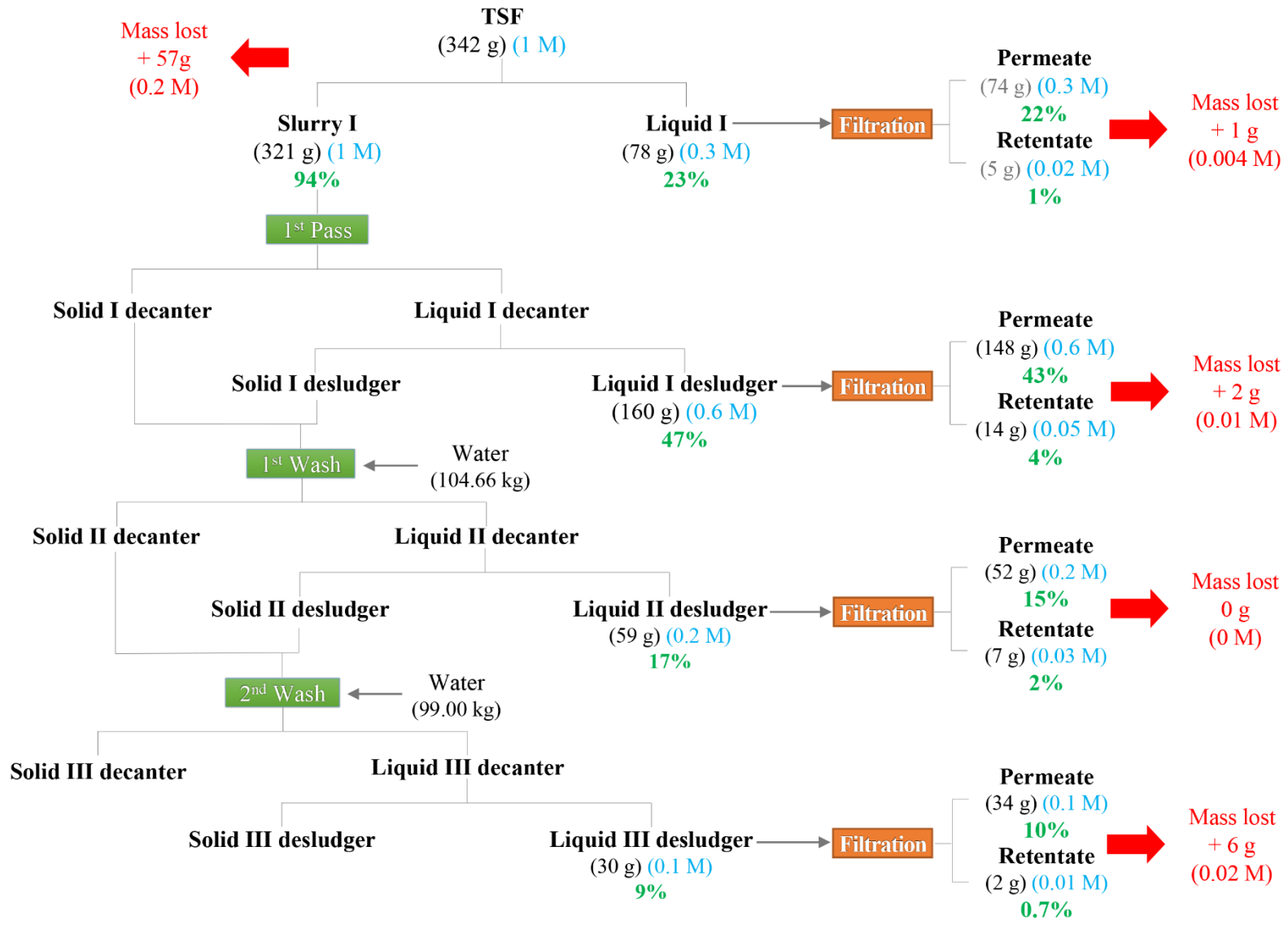
TSF
(342 g) (1 M)
Mass lost
+ 57g
(0.2 M)
Slurry I
(321 g) (1 M)
94%
Liquid I
(78 g) (0.3 M)
23%
Filtration
Permeate
(74 g) (0.3 M)
22%
Retentate
(5 g) (0.02 M)
1%
Mass lost
+ 1 g
(0.004 M)
1st Pass
Solid I decanter
Liquid I decanter
Solid I desludger
Liquid I desludger
(160 g) (0.6 M)
47%
Filtration
Permeate
(148 g) (0.6 M)
43%
Retentate
(14 g) (0.05 M)
4%
Mass lost
+ 2 g
(0.01 M)
1st Wash
Water
(104.66 kg)
Solid II decanter
Liquid II decanter
Solid II desludger
Liquid II desludger
(59 g) (0.2 M)
17%
Filtration
Permeate
(52 g) (0.2 M)
15%
Retentate
(7 g) (0.03 M)
2%
Mass lost
0 g
(0 M)
2nd Wash
Water
(99.00 kg)
Solid III decanter
Liquid III decanter
Solid III desludger
Liquid III desludger
(30 g) (0.1 M)
9%
Filtration
Permeate
(34 g) (0.1 M)
10%
Retentate
(2 g) (0.01 M)
0.7%
Mass lost
+ 6 g
(0.02 M)

Figure S9.