

Supplementary Material

The mean square and p -values are reported in Tables S1 to S6. A replication effect was observed in TS, fat, lactose, and CP content of both retentate and permeate, and in the ash content of the permeate (Table S1). The replication effect was also observed in the CP/TS ratio of retentate (Table S1). The significant ($p < 0.05$) replication effect was due to small compositional differences in the different lots of skim milk, as well as small differences in the actual concentration factor achieved in MF and UF processing in each replicate.

There was a significant ($p < 0.05$) replication effect observed in NPN, true protein (TP), CN, CN/CP, CN/TP, SP/CP, and SP/TP content of the retentates (Table S2). The significant replication effect was expected because of small differences in actual concentration factor achieved in MCC and MPC retentate during processing of the skim milk in each replicate. There was a significant ($p < 0.05$) effect of treatment on all the protein and protein ratios of permeate, except for CN and the CN/CP ratio (Table S3).

The mean square values and the p -values (in parentheses) for the percent SP, ash, calcium, and lactose removal from MFR and UFR produced using MF and UF respectively are shown in (Table S4). The replicate effect was significant ($p < 0.05$) for calcium removal and the treatment effect was significant ($p < 0.05$) for percent SP, ash, calcium, and lactose removal. The significant ($p < 0.05$) effect of the replication on calcium removal can be attributed to small compositional differences in the different lots of skim milk, as well as to small differences in the actual concentration factor achieved in MF and UF processing in each replicate (Table S4).

The mean square values and the p -values (in parentheses) are shown in Table S5.

There was a significant ($p < 0.05$) replication effect observed in α S1-CN, α S2-CN, κ -CN, peptides, and NPN content. Additionally, a significant ($p < 0.05$) treatment effect was observed in all the protein fractions, except κ -CN and NPN content measured by CGE. The mean square values and

the p -values (in parentheses) for the protein fractions in the CGE electrophoreogram of the MFP and UFP are shown in Table S6.

Table S1 Mean squares and *p*-values (in parentheses) of the retentate and permeate produced during microfiltration and ultrafiltration of skim milk using polymeric spiral-wound membranes

Factor	df	Retentate, %							Permeate, %					
		TS	Fat	Lactose	Ash	Ca	CP	CP/TS	TS	Fat	Lactose	Ash	Ca	CP
Replicate	2	0.6022*	0.0437*	0.0218*	0.0014	0.00008108	0.5227*	0.8852*	0.0029*	0.00123*	0.0321*	0.0024*	0.0000010	0.00066*
		(0.009)	(0.0001)	(0.008)	(0.115)	(0.063)	(0.015)	(0.028)	(0.040)	(<0.0001)	(0.001)	(0.032)	(0.436)	(0.031)
Treatment ¹	1	25.70*	0.00083	3.11*	0.0675*	0.0010083*	7.70*	61.38*	2.52*	0.0000083	2.37*	0.0000000	0.0000163*	0.0867*
		(<0.0001)	(0.244)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	(0.545)	(<0.0001)	(0.0000000)	(0.005)	(<0.0001)
Error	8	0.0667	0.00053	0.0023	0.00050	0.00002027	0.0694	0.1539	0.00059	0.000021	0.00175	0.00045	0.0000011	0.0727

*Statistically significant at $p < 0.05$

TS = Total solids

CP = total nitrogen \times 6.38

¹Treatment= MF and UF

Table S2 Mean squares and *p*-values (in parentheses) of the retentate (MFR¹ and UFR²) protein content and various protein ratios produced during microfiltration and ultrafiltration of skim milk using polymeric spiral-wound membranes

Factor	d f	NCN	NPN	TP	CN	SP	CN/CP	CN/TP	SP/CP	SP/TP	NPN/CP	Nitrogen
Replicate	2	0.0073 (0.184)	0.0002 (0.005)*	0.5063 (0.013)*	0.4339 (0.007) *	0.0072 (0.205)	0.4923 (0.009)*	0.5436 (0.010)*	0.5405 (0.011)*	0.5436 (0.010)*	0.0013 (0.218)	0.0013 (0.226)
Treatment ³	1	6.77 (<0.0001) *	0.0065 (<0.0001) *	7.22 (<0.0001) *	0.0310 (0.422)	6.31 (<0.0001) *	309.07 (<0.0001) *	296.81 (<0.0001) *	290.67 (<0.0001) *	296.81 (<0.0001) *	2.883 (<0.0001) *	0.3008 (<0.0001) *
Error	8	0.0035	0.000015	0.0696	0.0434	0.0037	0.0547	0.0633	0.0638	0.0633	0.0007	0.0007

*Statistically significant at $p < 0.05$

CP = total nitrogen \times 6.38; NCN = non-casein nitrogen \times 6.38; NPN = non-protein nitrogen \times 6.38; TP = true protein (CP – NPN); casein (CN) = CP – NCN; serum proteins (SP) = TP – casein

¹MFR= micellar casein concentrate retentate

²UFR= milk protein concentrate retentate

³Treatment= MFR and UFR

Table S3 Mean squares and *p*-values (in parentheses) of the permeate (MFP¹ and UFP²) protein content and various protein ratios produced during a microfiltration and ultrafiltration of milk using polymeric spiral-wound membrane

Factor	df	CN/C										
		NCN	NPN	TP	CN	SP	P	CN/TP	SP/CP	SP/TP	NPN/CP	NPN/TP
Replicate	2	0.000258	0.00	0.00053	0.0001	0.00041	18.94	207.58	22.97	207.58	37.80	228511.24
		(0.075)	(1.00)	(0.120)	1 (0.477)	(0.018)*	(0.420)	(0.156)	(0.011)*	(0.156)	(0.291)	(0.389)
Treatment	1	0.0784	0.0021	0.1141	0.0002	0.1064	26.23	15859.51	10124.51	15859.51	9120.71	2401929.5
³		(<0.0001)	(<0.0001)	(<0.0001)	1 (0.247)	(<0.0001)	(0.281)	(<0.0001)	(<0.0001)	(<0.0001)	(<0.0001)	4 (0.010)*
		*	*	*		*		*	*	*	*	
Error	1	0.000071	0.000021	0.00019	0.0001	0.000058	19.58	87.64	2.80	87.64	24.73	214439.67
	3				3							

*Statistically significant at $p < 0.05$

TS = Total solids

CP = total nitrogen \times 6.38; NCN = non casein nitrogen \times 6.38; NPN = non-protein nitrogen \times 6.38; TP = true protein (CP – NPN); casein (CN) = CP – NCN; serum proteins (SP) = TP – casein

¹MFP= micellar casein concentrate permeate

²UFP= milk protein concentrate permeate

³Treatment= MF and UF

Table S4 Mean squares and *p*-values (in parentheses) of percent removal of SP¹, ash, calcium and lactose content during microfiltration and ultrafiltration of skim milk using polymeric spiral-wound membranes

Factor	df	SP	Ash	Calcium	Lactose
Replicate	2	9.70 (0.293)	0.5059 (0.594)	5.78 (0.038)*	1.53 (0.194)
Treatment ²	1	6417.05 (0.006)*	21.17 (0.033)*	17.07 (0.013)*	61.70 (0.006)*
Error	2	4.02	0.7406	0.2302	0.3662

*Statistically significant at $p < 0.05$

¹SP=Serum proteins = TP – casein

²Treatment = MF (microfiltration) and UF (ultrafiltration)

Table S5 Mean squares and *p*-values (in parentheses) of the individual protein fractions observed in capillary gel electrophoresis of retentate (MFR¹ and UFR²) produced during microfiltration and ultrafiltration of skim milk using polymeric spiral-wound membranes

Factor	d f	β-CN	αS1-CN	αS2-CN	κ-CN	γ-CN	α-LA	β-LG	Others SP ³	NPN	CN	SP	NPN
Replicate	2	0.1350 (0.388)	3.18 (0.019)*	0.8330 (0.0387)*	0.9478 (0.068) *	0.2449 (0.308)	0.042 (0.1214)	0.2428 (0.164)	0.0331 (0.076)*	0.5569 (0.025) *	0.9430 (0.154)	0.5954 (0.105)	0.5569 (0.025) *
Treatmen t ⁴	1	42.54 (<0.0001) *	36.15 (<0.0001) *	35.82 (<0.0001) *	0.2404 (0.377)	1.13 (0.029) *	23.94 (<0.0001) *	105.13 (<0.0001) *	0.677 (<0.0001) *	0.0242 (0.653)	249.69 (<0.0001) *	254.78 (<0.0001) *	0.0242 (0.653)
Error	1 4	0.1333	0.5951	0.2012	0.4524	0.1908	0.0194	0.1176	0.011	0.115	0.4401	0.2236	0.115

*Statistically significant at $p < 0.05$

¹MFR= micellar casein concentrate

²UFR= milk protein concentrate

³Others SP= peptide peaks (10-20 kD) other than α-LA and β-LG

⁴Treatment = MF and UF

Table S6 Mean squares and *p*-values (in parentheses) of the individual protein fractions observed in capillary gel electrophoresis of permeate (MFP¹ and UFP²) produced during microfiltration and ultrafiltration of skim milk using polymeric spiral-wound membranes

Factor		β-CN	αS1-CN	αS2-CN	κ-CN	γ-CN	α-LA	β-LG	Other SP ³	NPN	CN	SP	NPN
Replicate	2	0.0019 (0.872)	0.00	0.00	0.00	0.00	0.4584 (0.138)	5.34 (0.1879)	29.03 (0.4013)	15.65 (0.624)	5.57 (0.1104)	24.72 (0.498)	15.65 (0.624)
Treatment ⁴	1	6.16 (<0.0001)) [*]	0.00	0.00	0.00	0.00	2546.60 (<0.0001)) [*]	11261.50 (<0.0001)) [*]	816.89 (0.0001)) [*]	17025.05 (<0.0001)) [*]	341.82 (<0.0001)) [*]	12542.11 (<0.0001)) [*]	17025.05 (<0.0001)) [*]
Error	14	0.0135	0.00	0.00	0.00	0.00	0.2005	2.83	29.77	32.12	2.15	33.70	32.12

^{*}Statistically significant at *p* < 0.05

¹MFP= micellar casein concentrate permeate

²UFP= milk protein concentrate permeate

³Other SP= peptide peaks (10-20 kD) other than α -LA and β -LG

⁴Tretament = MF and UF