Preliminary studies on heat stability of high protein dairy beverages containing modified milk protein concentrate

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Abstract # T93

Abstract

Milk protein concentrates (MPC) are becoming a preferred source of protein in ready-to-drink dairy beverages. Calcium-mediated aggregation of proteins during storage is one of the main reasons for the failure of these beverages. In the current study, two batches each of MPC85 (control), 20% calcium reduced (MPC-20%), and 30% calcium reduced (MPC-30%) were evaluated in two phases and in duplicate. MPC-30% and MPC-20% exhibited the highest HCT of ~ 32 min at all levels of SHMP addition while MPC85-Control had the least HCT time of ~ 21-25 min at 0 and 0.15% SHMP. HCT of control (28.06 min) at 0.25% SHMP and HCT of MPC-30% (32.79 min) and MPC-20% (30.96 min) at 0% SHMP were not significantly different ($p>0.05$). In phase II, MPCs were reconstituted in a model dairy beverage formulation consisting of 5.07% of a mixture of gums (gellan gum, carrageenan, cellulose gel, and microcrystalline cellulose), maltodextrin, and sugar along with 0.12% potassium citrate. Formulations were homogenized and treated with three concentrations of SHMP after adjusting pH to 7. It was found that the presence of gums and sugar adversely impacted the HCT of the formulated model beverage. In the phase II study, MPC-20% at 0% SHMP exhibited the highest HCT of 9.33 min. This study shows the possibility of reduced levels of phosphate addition by using calcium reduced MPCs.

Introduction

- Milk protein concentrate powders (MPC) are high protein ingredients with caseins to whey proteins ratio the same as milk.
- Minerals retained during ultrafiltration effect the storage stability and functionality of MPC due to mineral-protein interactions.
- Research suggested that reducing the calcium also increased the solubility of the MPC powders.
- The objective of this study was focused on the application of calcium modified MPC in formulating a high protein dairy beverage.

Table 1. Compositions of the MPC powders used to formulate the high protein dairy beverage

MPC	Total solids (%)	Protein (%)	Calcium (%)
Control	94.73±0.18	80.77±0.02	2.21±0.04
MPC-20%	95.13±0.89	80.77±0.55	1.73±0.02
MPC-30%	94.70±0.17	80.02±0.14	1.47±0.02

Materials and Methods

- Two batches each of MPC85 (control), 20%-calcium reduced (MPC-20%), and 30%-calcium reduced (MPC-30%) were evaluated in two phases and in duplicate.

Phase I

- MPC powders were reconstituted to 8% protein in distilled water
- Adjusted pH to 7.0 and divided into three equal parts
- Sodium hexametaphosphate (SHMP) was added at three levels (0, 0.15, and 0.25%)
- Homogenized and heat stability was determined by measuring heat coagulation time (HCT) at 140°C

Phase II

- MPC powders were reconstituted to 8% protein solutions in distilled water along with model high protein dairy beverage formulation
- Model high protein dairy beverage formulation constituting 10.26% of mixture of gums, maltodextrin, sugar, and 0.12% potassium citrate was added to the solution
- pH of solution was adjusted to 7.0 and divided into three parts
- Sodium hexametaphosphate (SHMP) was added in 0, 0.15, and 0.25%
- Solutions were homogenized and heat stability was determined by measuring heat coagulation time (HCT) at 140°C

Results and Discussion

Table 2. Heat coagulation time (HCT) of the 8% protein solutions prepared in Phase I and Phase II

MPC	SHMP (%)	Phase I HCT (min)	Phase II HCT (min)
Control	0	20.95 ± 0.02^{c}	7.15 ± 0.04^{bc}
	0.15	25.29 ± 1.54^{bc}	8.86 ± 0.01^{ab}
	0.25	28.06 ± 0.22^{ba}	3.81 ± 0.82^{e}
20% Ca reduced	0	30.96 ± 0.33^{ba}	9.33 ± 1.35^{a}
	0.15	32.27 ± 1.17^{a}	4.85 ± 0.39^{de}
	0.25	32.65 ± 0.7^{a}	5.65 ± 0.05^{cde}
30% Ca reduced	0	32.79 ± 3.43^{a}	6.22 ± 1.42^{cd}
	0.15	32.43 ± 2.82^{a}	6.36 ± 1.98^{cd}
	0.25	32.15 ± 2.41^{a}	5.2 ± 0.11^{cde}

Values with same superscript are not significantly different ($p>0.05$). HCT values were compared within phases.

- In Phase I, 20 and 30% Ca reduced MPC formulations exhibited the highest heat stability. This increase was because of the increased stability in casein micelles with decreased calcium.
- However, in Phase II, MPC-20% with 0% SHMP exhibited high heat stability followed by control with 0 and 0.15% SHMP.
- In Phase II, reduced heat stability in 20% and 30% Ca reduced MPC formulations when SHMP was added was attributed to chelation of colloidal calcium phosphate to a critical level, which resulted in disruption of micellar structure integrity.
- Reduced heat stability was also attributed due to the chelating effect of 0.12% citrate and added SHMP in the formulation.

Conclusions

- In Phase I, as calcium was reduced, heat stability increased, whereas in Phase II, casein micelle dissociation and the presence of sugars, gums, and citrate (chelating agent) decreased heat stability in beverage formulations with calcium modified MPC.
- High protein dairy beverages formulated in Phase II from MPC-20% and in the presence of no phosphates exhibited high heat stability.
- This study shows the possibility of improved heat stability usage of reduced levels of phosphate when calcium reduced MPC were used in enteral dairy beverage formulation.

References

- de Kort, E., M. Minor, T. Snoeren, T. van Hooijdonk, and E. van der Linden. 2011. Effect of calcium chelators on physical changes in casein micelles in concentrated micellar casein solutions. Int Dairy J 21:907–913.
- Marella, C., P. Salunke, A.C. Biswas, A. Kommineni, and L.E. Metzger. 2015. Manufacture of modified milk protein concentrate utilizing injection of carbon dioxide. J Dairy Sci 98:3577–3589. doi:10.3168/jds.2014-8946.
- Pitkowski, A., T. Nicolai, and D. Durand. 2008. Scattering and turbidity study of the dissociation of casein by calcium chelation. Biomacromolecules 9:369–375. doi:10.1021/bm7006899.