International Journal of
Dairy Science

ISSN 1811-9743

Academic
Journals Inc.

www.academicjournals.com

International Journal of Dairy Science 2 (2): 159-165, 2007
ISSN 1811-9743

Foaming Properties of Casein Glycomacropeptide in the Presence of ι- and κ-Carrageenans

M.H. Abd El-Salam, A.F. Farrag, H.M. El-Etriby and F.M. Assem
Department of Dairy, National Research Centre, Dokki, Cairo, Egypt

Abstract: The foaming properties of casein glycomacropeptide (GMP) solutions were studied in the presence of different concentrations (0.0-0.1%) of ι- and κ-carrageenans at pH 6, 5 and 3 before and after heat treatment at 80°C 10 min. The foaming properties of these solutions were assessed through their foaming capacity and stability. Addition of carrageenans improved markedly the foam capacity and stability of GMP solution. Heating improved slightly the foaming capacity and stability of solutions at pH 5 and 6. At pH 3, heating decreased significantly the foaming capacity and stability of GMP/carrageenans solutions. GMP solution containing 0.05% ι-carrageenan showed the optimum foam capacity and stability. The obtained results can help in formulating aerated food products containing GMP as a source of proteins.

Key words: Casein glycomacropeptide, carrageenans, foam capacity, foam stability

INTRODUCTION

Foam formation is a basic step in the manufacture of many foods including cake, bread, ice cream and confectionary products (Campbell and Moougeot, 1999). Producing foam involves the generation of a protein film surrounding a gas bubble and the packaging of gas bubbles into an overall structure. Subsequently, formed foams undergo destabilization due to creaming, drainage, bubble coalescens and disproportionation (Foegeding *et al*., 2006). Therefore, the foaming properties of proteins are based on two attributes; namely foaming capacity (overrun) and foam stability. Proteins vary widely in foaming properties, depending on their structure and surface hydrophobicity and viscoelasticity.

The foaming properties of protein solutions undergo modification with technological treatments, pH, ionic strength and the presence of co-solutes (Nino ad Patino, 2002; Phillips *et al*., 1990; Zhu and Damodaran, 1994).

Addition of polysaccharides had variable effects on the foaming properties of protein solution. Thus xanthan gum enhanced the adsorption of legume proteins at a/w interfaces and increased their foam stability (Makari *et al*., 2005, 2006). The overrun of sunflower protein stabilized foams was decreased in the presence of all non-surface active polysaccharides (Martinez *et al*., 2005). The foam stability of egg proteins was enhanced in the presence of pectin (Ibanoglu and Erwlebi, 2006). The presence of κ-carrageenan reduced the foam capacity (overrun) of β-lactoglobulin solution but increased foam stability (Carp *et al*., 2004).

Casein glycomacropeptide (GMP) arises from the action of chymosin on k-casein during cheese manufacture. This peptide is free of phenylalanine and other aromatic amino acids. Therefore, it is a potential ingredient in processed foods for subjects suffering from phenylkitonrea (Brody, 2000). The unique composition of GMP affects its functional properties. Also, the low molecular weight (i.e., 8000 Dalton) and the high carbohydrate moiety and negative charge (Brody, 2000) are responsible for its characteristic functionality.

Corresponding Author: M.H. Abd El-Salam, Department of Dairy, National Research Centre, Dokki, Cairo, Egypt

The only cited report on foaming properties of GMP (Marchall, 1991) revealed high overrun but inferior stability for 10% GMP solution. Therefore, Marchall (1991) failed to prepare aerated food products containing GMP.

During the course of study on the functional properties of GMP, trials were carried out to improve the foaming properties by additive polysaccharides. The present paper presents results obtained for foaming properties of GMP solution as affected by added different concentrations of ι- and κ-carrageenan at different pH values and heat treatment.

MATERIALS AND METHODS

Materials

- Casein glycomacropeptide (GMP). The GMP was a commercial product (Lactoprodan® CGMP-10) obtained as a gift from Arla Foods Ingredients (Viby, Denmark). It had 85%±2% protein, 2% lactose, 0.5% fat, 6.5% ash, 5.5% moisture, 80% GMP and 4.2% sialic acids (data of the supplier).
- κ and ι- carrageenans were obtained from Sanofi Bioindustries (Carentan, France).

Methods

The foaming properties of 0.5% GMP solutions were characterized through their foam capacity (volume of formed foams in mL) and stability (decrease of foam volume over time) measured by gas sparging .

Aliquot (50 mL) of GMP solution was placed in 250 mL cylinder. Nitrogen gas was blowed in the GMP solution at a flow rate of 50 mL min^{-1} through a porous glass filter at the bottom of the cylinder. Gas blowing was continued for 10 min and the height of the formed foam was measured and recorded as foam capacity. The decrease in the foam height (foam stability) was measured at 2 min intervals until foams disappeared or for 50 min. Foaming properties were measured at 25°C from 0.5% GMP solutions containing 0, 0.025, 0.05 and 0.1% ι- or κ-carrageenan at pH 6, 5 and 3 before and after heating at 80°C/10 min. Each measurement was repeated twice and the whole experiment was replicated.

Linear regression analysis was carried out for obtained results using vassarstat.com computing center.

RESULTS AND DISCUSSION

Foaming Capacity

Table 1 shows that the foaming capacity of GMP solution without additives was affected slightly by the pH of the solution. κ- and ι-Carrageenan solutions (0.025-0.1%) failed to show any foam formation. However, when carrageenans were added to the GMP solution they increased markedly the foaming capacity of the GMP solution. Both κ- and ι-carrageenans behaved similarly in their effect on the foaming capacity of GMP solution. Increasing the concentration of the added carrageenans increased the foaming capacity of the GMP solution except in the case of 0.1% ι-carrageenan at pH 6 where it showed less foaming capacity than the lower ι-carrageenan concentrations. The increased foaming capacity can be attributed to GMP/carrageenan interactions the increased protein adsorption on the interface (Makari *et al*., 2005; Martinez *et al*., 2005). The increase in foaming capacity of GMP solutions containing carrageenans was more pronounced at low pH value. Thus contrary to the decreasing effect of low pH on the foaming capacity of GMP solution, the decrease of pH from 6 to 3 increased markedly the foaming capacity of GMP/carrageenan solutions. At low pH GMP would carry less negative charge (Brody, 2000) which may increase its interaction with carrageenans.

Table 1: Foaming capacity (mL) of 0.5% GMP solution in the presence of different concentrations of κ- and ι-carrageenans and pH values before and after heating at 80°C/10 min

	Carrageenan (%)							
	0.0		0.025		0.05		0.10	
pH	A*	B*	A*	B*	A*	B*	A*	B*
κ-carrageenan								
6	75	100	100	190	150	180	270	290
5	65	120	110	170	210	230	300	310
3	60	75	230	90	280	90	340	130
ι-carrageenan								
6	75	100	160	210	170	190	130	270
5	65	120	210	230	210	220	270	300
3	60	75	220	180	250	180	360	190

*A, before heating; B, after heating

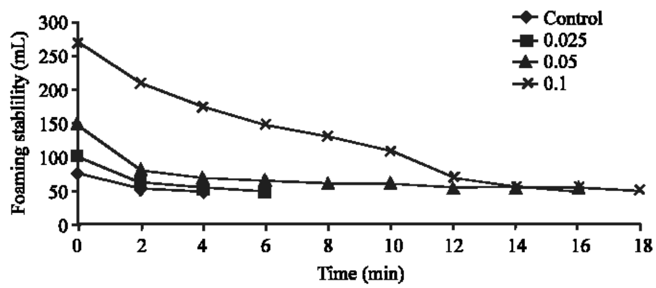

Fig. 1: Foaming stability of GMP 0.1% as affected by κ-carrageenan % added without heating at pH 6.0

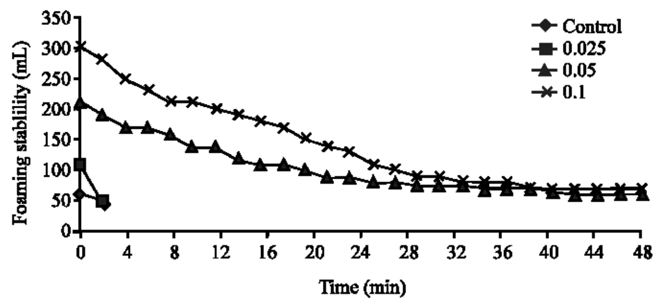

Fig. 2: Foaming stability of GMP 0.1% as affected by κ-carrageenan % added without heating at pH 5.0

Heating of the GMP solution and GMP/carrageenan solutions at 80°C/10 min (pH 6 and 5) increased slightly their foaming capacities. However, at pH 3, heating GMP/carrageenans solutions decreased considerably their foaming capacities. In the mean time a precipitate was apparent at the high carrageenan concentration (0.1%) probably of GMP/carrageenans aggregates.

Foam Stability

Figure 1-11 show the foam stability curves for GMP and GMP/carrageenans solutions of different pH values before and after heating at 80°C/10 min. The GMP solution had a very low foam stability in accordance with previous report (Marchall, 1991). Addition 0.025% of κ-carrageenan to GMP solution at different pH values had a limited effect on its foam stability. However, addition of 0.05% and 0.1% κ-carrageenan improved markedly the foam stability of GMP solution at pH 5 before

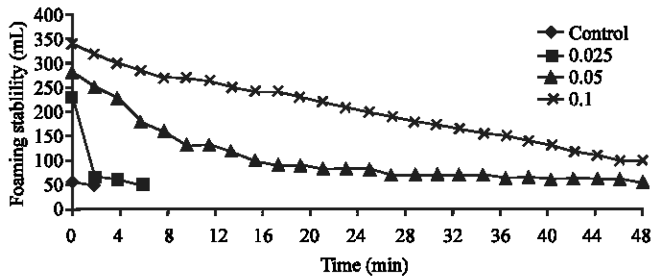

Fig. 3: Foaming stability of GMP 0.1% as affected by κ-carrageenan % added without heating at pH 3.0

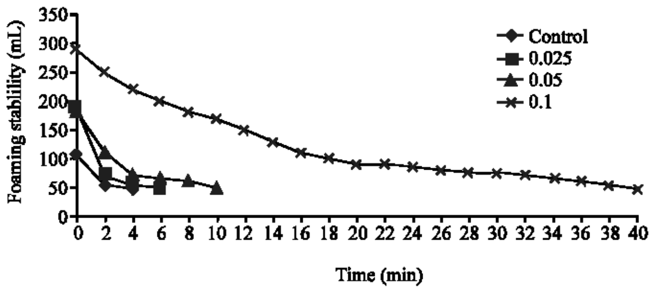

Fig. 4: Foaming stability of GMP 0.1% as affected by κ-carrageenan % added, heating at 80°C/10 min at pH 6.0

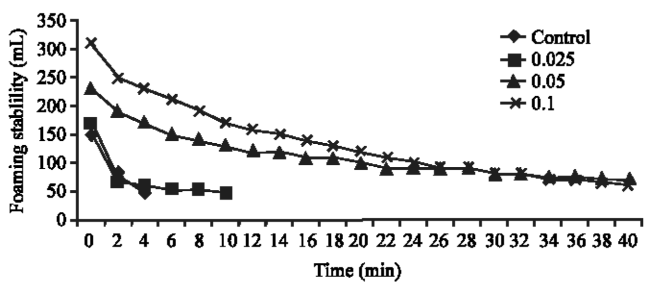

Fig. 5: Foaming stability of GMP 0.1% as affected by κ-carrageenan % added, heating at 80°C/10 min at pH 5.0

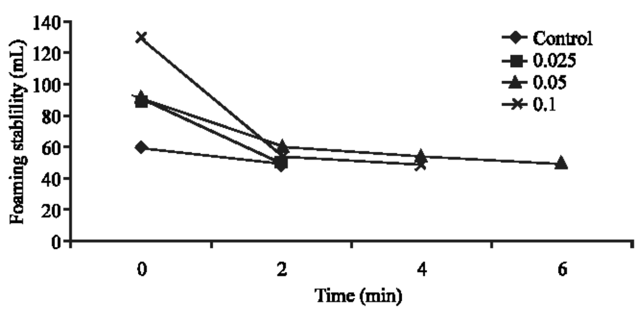

Fig. 6: Foaming stability of GMP 0.1% as affected by κ-carrageenan % added, heating at 80°C/10 min at pH 3.0

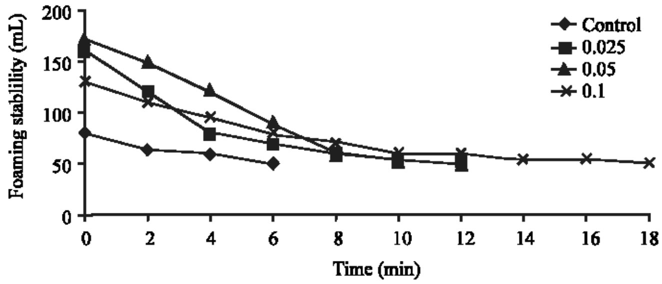

Fig. 7: Foaming stability of GMP 0.1% as affected by ι-carrageenan % added without heating at pH 6.0

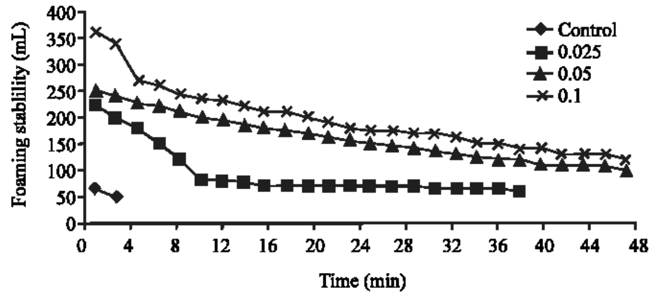

Fig. 8: Foaming stability of GMP 0.1% as affected by ι-carrageenan % added without heating at pH 3.0

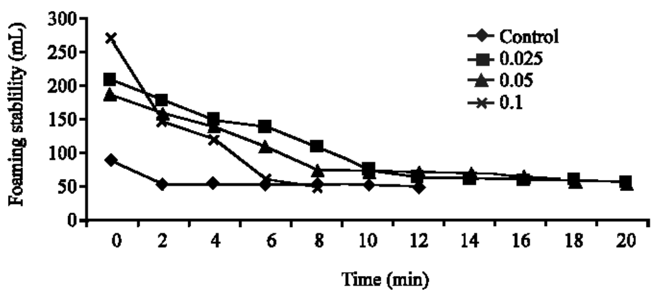

Fig. 9: Foaming stability of GMP 0.1% as affected by ι-carrageenan % added heating at 80°C/10 min pH 6.0

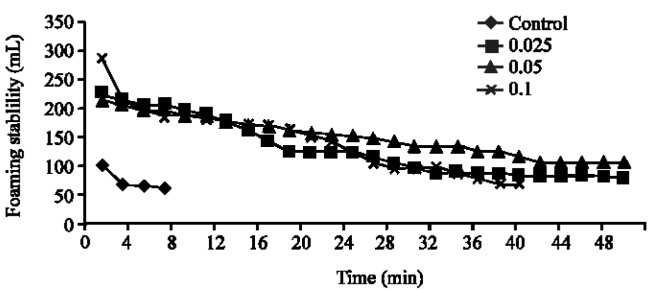

Fig. 10: Foaming stability of GMP 0.1% as affected by ι-carrageenan % added, heating at 80°C/10 min pH 5.0

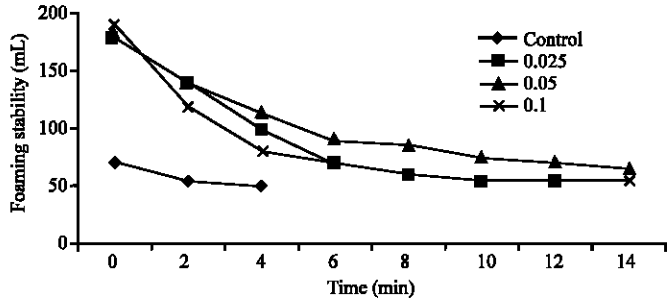

Fig. 11: Foaming stability of GMP 0.1% as affected by ι-carrageenan % added heating at 80°C/10 min pH 3.0

and after heating at 80°C/10 min and pH 3 without heating. The foam stability of the GMP solution was improved with the addition of ι-carrageenan at all concentration used at pH 5 before and after heating and at pH 3 without heating. At pH 6 the foam stability of GMP/ι-carrageenan solution was less than at lower pH values. In all cases regression analysis showed close correlation between foam volume and time with r> -0.90 and r^2 >0.80. However, the slope of the regression line was affected by the concentration of the added carrageenan. Generally, the slope was less in solutions containing 0.05% carrageenan (-2.51 to -2.92) than that containing 0.025% carrageenan (-3.22 to -3.53) and that containing 0.1% carraggenan (- 3.03 to -4.79). This suggest that foams of GMP solution containing 0.05% carrageenan was more stable than that containing other carrageenan concentrations (Fig. 1-11). The increased foam stability of foam stability was probably due to the viscosity increase and the creation of a network which would prevent the air droplets from coalescence (Makari *et al*., 2005).

CONCLUSIONS

The foam capacity and stability of GMP solution can be improved by the addition of κ- and ι-carrageenans. However, the optimum foam capacity and stability of 0.5% GMP solution can be obtained with addition of 0.05% ι-carrageenan at pH 5 with or without heating. This can help in the formulation of aerated food products containing GMP as protein source..

REFERENCES

Brody, E.B., 2000. Biological activities of bovine glycomacropeptide. Br. J. Nutr., 84 (Supplement 1): S39-S46.

Campbell, G.M. and E. Mougeot, 1999. Cream and characterization of aerated food products. Trends in Food Sci. Technol., 10: 283-296.

Carp, D.J., R.I. Baeza, G.B. Bartholomai and A.M.R. Pilosof, 2004. Impact of proteins-κ-carrageenan interactions on foam properties. Lebensmittel-Wissenschaft und Technologie, 37: 573-580.

Foegeding, E.A., P.J. Luck and J.P. Davis, 2006. Factors determining the physical properties of protein foams. Food Hydrocolloids, 20: 284-292.

Ibanoglu, E. and E.A. Erelebi, 2006. Thermal denaturation and functional properties of egg proteins in the presence of hydrocolloid gums. Food Chem. (In Press).

Makari, E., E. Papalamprou and G. Duxastakis, 2005. Study of functional properties of seed storage proteins from indigenous European legume crops (lupin, pea, broad bean) in admixture with polysaccharides. Food Hydrocolloids, 19: 583-594.

Makari, E.A. and G.I. Duxastakis, 2006. Surface tension of *Phasseolus vulgaris* and *coccineus* proteins and effect of polysaccharides on their foaming properties. Food Chem., (In Press).

Marshall, S.C., 1991. Casein macropeptide from whey. A new product opportunity. Food Res. Quart., 51: 86-91.

Martinez, K.D., R.I. Baeza, F. Millan and A.M.R. Pilosof, 2005. Effect of limited hydrolysis of sunflower protein on the interactions with polysaccharides in foams. Food Hydrocolloids, 19: 361-369.

Nino, M.R.R. and J.M.R. Patino, 2002. Effect of the aqueous phase composition on the adsorption of bovine serum albumin to the air-water interface. Ind. Eng. Chem. Res., 41: 1489-1495.

Phillips, L.G., W. Schulman and J.E. Kinsella, 1990. pH and heat treatment effects on foaming of whey protein isolates. J. Food Sci., 55: 1116-1119.

Zhu, H.M. and S. Damodaran, 1994. Proteose peptones and physical factors affect foaming properties of whey protein isolate. J. Food Sci., 59: 554-560.