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Effect of Heating on the Functional Properties of Whey Proteins Concentrate in a Model System

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Abstract: The use of Whey Protein Concentrates (WPC) as functional ingredients has increased significantly during the last 20 years. These proteins are used in many food systems. WPC are rapidly denaturated and unfolded by heating aboove 65°C. A model system was used to investigate in the influence of WPC on the viscosity of the system. The viscosity of the model system decreased significantly by the presence of WPC in replacement of sucrose specially at high temperature.

Key words: Model system, whey protein concentrates, viscosity

INTRODUCTION

The term functional properties is generally used in realtion to physico-chemical parameters of proteins in simple model systems (Dewitt, 1990; Kinsella *et al*., 1989; Morr and Ha, 1993). The functional properties of whey proteins might be defined as those physico-chemical properties wich contribue to desired characteristics in many food products (Freud, 1995; Franke *et al*., 2002; Koster, 1989; Leroy, 2000). The thermal denaturation of whey proteins and their heat-induced unfolding expose hydrophobic amino acid residues and affect the structure and properties of whey proteins either reversibly or irreversibly. The heat denaturation of whey protein and their functional properties in food products are studied: preparation of acid gels from heated pH adjusted skim (Amena *et al*., 2004), development of milk properties and the consumer acceptance of milk chocolate (Bolenz *et al*., 2004), determination of and rheological properties and the thermal gelation of whey proteins concentrates (Gauld *et al*., 1990), thermal denaturation of whey proteins in heat-procced milks was determined (Mangi and Kakuda, 1987), heat denaturation of whey protein was studied (Dong Jang and Swaisgood, 1990), influence of thermal processing the properties of dairy colloids was determined (Livney *et al*., 2003), determination of influence of pH on the heat-induced aggregation of model milk (Sweeney *et al*., 2004). These amino acid residues which result of hydrophobic interactions were originally located in the hydrophobic interior of the protein molecule (Krueger *et al*., 2002). The Caseins concentrates were not influenced by heating (Lorient, 1977).

The results obtained on the functional properties of whey protein concentrates denatured thermally in no aqueous food (chocolate) by conching method might be investigated by another technic.

MATERIALS AND METHODS

At the laboratory of Biophysico-chemical and Technology Alimentary of Compiegne University of Technology (France) in 2004, were prepared white chocolate for example on adding whey proteins concentrates or caseins (proteins concentrates whey proteins and casein were prepared at French EURIAL Company) in replacement of powder whole milk. The system model studied were consisted of 70% sucrose powder and 30% cocoa butter (prepared at Côte d'Ivoire) to investigate Whey Protein Concentrates (WPC) or caseins behaviour in presence of fat food. Powder of commercial sucrose and a predefined quantity of malted cocoa butter (45°C) were mixed to obtain a plastic paste. The ingredients were mixed for 20 min in a Guitard kneader while maintaining the temperature at 45°C.

After mixing, the mass is firely ground 2 times on a 3 rolls refiner Grenier Charvet with decreasing space between the rolls. Refining was followed by conching in the same kneader at different temperatures for different times, after adjusting the percentage of cocoa butter.

Measurement of casson plastic viscosity: In the laboratory of Biophysico-chemical and Technology Alimentary of Compiegne University Technology, the Casson plastic viscosity were determined on measuring the paste of chocolate by Rheomat 108 and the value of the viscosity were obtained by computer. This method presently were used by chocolate manufacture. The different preparations were carried out using Rheomat 108 according to Chocolate and Cocoa International Office method OICC, (Casson, 1973). All data were studied by the analysis of variances. The means were compared using Ducan's multiple range test (Ducan, 1955)

RESULTS AND DISCUSSION

The influence of conching temperature and conching time on the viscosity of chocolate has been studied. Whey protein concentrates (1.5%) were added to white chocolate in replacement of sucrose (1.5%). Figure 1 and 2 show the evolution of white chocolate viscosity during conching. The viscosity of chocolate without whey protein concentrates was constant during the conching temperature. There was no difference on the value of the viscosity for 26 h of conching at different temperatures. In presence of whey protein concentrates, the viscosity of chocolate was decreased at high conching temperature. This confirmed the results of (Franke *et al.*, 2002.)

The analysis of these results shows that there was a significant difference ($p<0.05$) between the different treatments. A significant difference ($p<0.01$) was obtained between the samples with 8 and 26 h of conching time, the same difference was obtained with the samples that the conching temperature were realized between 65 and 95°C (Fig. 2).

The most significant results were obtained for the samples conched at 95°C for 26 h. In these conditions, the viscosity of the model system decreased more than 50% of its initial value. This would indicate that the whey protein concentrates could be unfolded at high temperature and this could confirm the results obtained by (Morr and Ha, 1993). When native globular whey proteins are heated above 65-70°C, they partially unfold because of the physical forces favouring the unfolding of the proteins.

The evolution of the viscosity of the model system by replacement of cocoa butter and sucrose by WPC in function of conching temperature was showed on Fig. 3. The substitution of 1.5% of cocoa butter by 1.5% of WPC shows a significant difference for the treatment at 75°C and for conching temperature at 85 and 95°C, but there was no significant difference at 65°C. This Fig. 3 also shows the comparative study between the replacement of sucrose and cocoa butter by WPC at different temperatures only for 26 h of conching. In both cases, the viscosity of chocolate decreased linearly with the conching temperature.

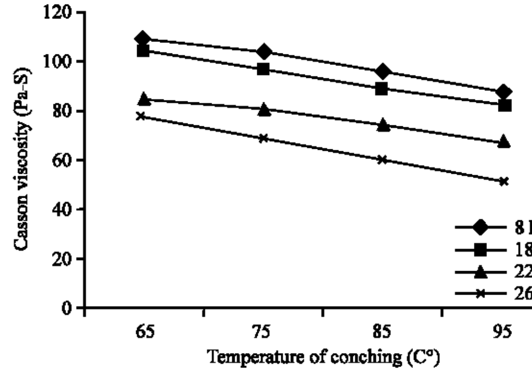

Fig. 1: Influence of conching temperature on the viscosity of model system in presence WPC

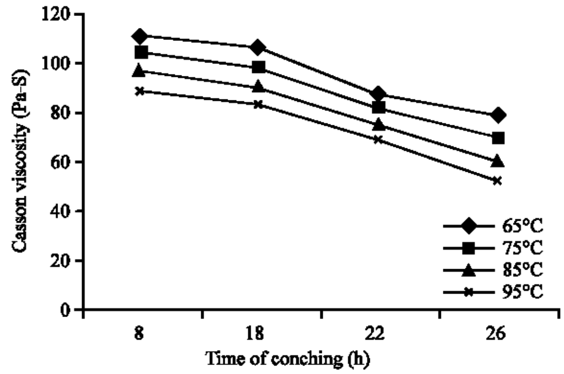

Fig. 2: Influence of the time conching on the viscosity of model system in presence WPC

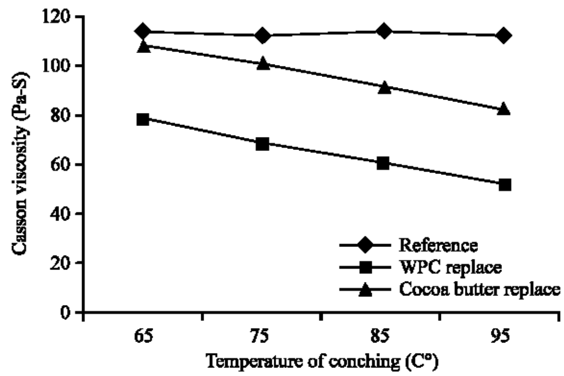

Fig. 3: Influence of the replacement of 1.5% of cocoa butter and of 1.5% of sucrose by WPC at different temperatures of conching during 26 h

The replacement of cocoa butter by WPC is less significant that the replacement of sucrose by WPC. At high temperature (95°C), the viscosity of chocolate decreased more than 50% of its initial value when WPC replaced sucrose and only 25% when WPC replaced cocoa butter. These results obtained are very interesting and applicable to any food in which the objective of the

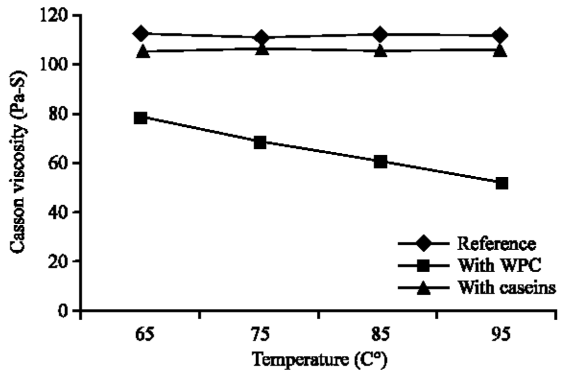

Fig. 4: Influence of the replacement of 1.5% of sucrose by WPC and by caseins at different temperatures of conching for 26 h

food technologist is to replace fat by protein ingredient. A comparative study has been realized between the influence of WPC and caseins on the viscosity of chocolate at different temperatures (Fig. 4).

The replacement of sucrose by caseins only shows a significant difference for all treatments. But there was no difference of the value of the viscosity of the samples at different conching temperatures. This confirmed the results of (Lorient, 1977). This confirmed that heating processing would not unfold caseins, as it is noticed with WPC (Kinsella *et al.*, 1989). Using WPC would decrease the viscosity of chocolate by 10-40% more than samples with the same percentage in caseins.

CONCLUSIONS

A better knowledge of WPC in the model system is essential for their possible utilization and application in fat food system. They have found a widespread use as functional ingredients in food industry. Whey protein concentrates were also used in replacing of the soya lecithin in chocolate manufacture. They significantly decreased Casson viscosity and added in chocolate its nutritional value.

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