

## Original paper

# The possibility of using fluid whey in comminuted meat products: capacity and viscosity of the model emulsions prepared using whey and muscle proteins

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**Abstract.** The emulsion capacity (EC) of whey and sarcoplasmic proteins were low when they were used alone, but the EC and viscosity (EV) of total meat proteins (TMP) were higher than those values of other proteins investigated, including a combination of whey plus TMP. However, the solubility of the TMP proteins was lower than that of the other proteins investigated, probably due to the differences in the physico-chemical properties of whey and muscle proteins and the buffer used. In general, EC of whey proteins showed a significant alteration when used in combination with muscle proteins, while its solubility was not changed. The present results suggest that it is possible to use fluid whey in emulsion-type meat products and these studies should continue using actual meat emulsion systems.

## Introduction

Non-meat additives with a high protein content have been used increasingly in the manufacture of emulsion-type meat products, and this has resulted in the production of more stable meat products with better textural and nutritional properties [1]. Functionality of the food proteins refers to their ability to give desired properties, as assessed by analytical or sensory means. In batter-type meat products, the ability of meat binders and extenders to absorb and retain a substantial amount of water is considered to be a critical functional property. Milk proteins are one of the best moisture binders among the extenders in meat products, although they have a lower emulsifying effect on soluble protein bases [2–3].

There are several functional quality parameters which have been developed for the evaluation of emulsions, such as emulsion capacity (EC), emulsion stability (ES), emulsion viscosity (EV), gel strength (GS) as well as water and fat binding capacity. In general, these functional quality

criteria in meat emulsions are influenced by the content of the meat proteins, proportion of stroma proteins, conformational status of the proteins and emulsion preparation technique or conditions [2, 4–6].

Functional properties of milk and whey proteins, such as EC, ES and gelation characteristics have received considerable attention in the last two decades [7]. Uraz et al. [8] reported that in the manufacture of cheese, about 90% of the milk is converted into whey, which contains approximately 93% water and 7% solids (5% lactose, 1% protein and 1% minerals, etc.).

There has not been much use of whey liquid, concentrate or products in the food or feed industries in many parts of the world. For example, about 10 million tons of excess fluid whey is produced every year, but only one-third of this liquid is used as food or feed [9]. Whey products, containing very nutritive and functional proteins, are relatively cheap. Hence, much research has been conducted to develop ways of utilizing this economic protein source in the manufacture of different food products [10–12]. The information about meat emulsions, particularly with milk and whey proteins, has not been made widely available, and there is very limited information concerning the emulsion characteristics of fluid whey in conjunction with different meat proteins [13]. Also, there has been tremendous concern to utilize whey proteins or products in food processing in order not to waste this invaluable protein and mineral source. Hence, it is important to obtain reliable, practical, technical and scientific information concerning whey proteins in emulsion-type products, so as to produce better meat emulsions whilst utilizing whey. The meat industry uses whey protein concentrates (WPC) or dried milk proteins, but not fluid whey, in actual comminuted products, despite the extra costs incurred and energy consumed in the processes of concentrating and drying the fluid whey. Adding fluid whey directly to the meat products requires almost no expense at all, other than that of cooling. The objective of this experiment was to investigate the emulsion quality criteria and the possibility of using fluid whey in conjunction with different meat proteins in model meat emulsion systems.

## Materials and methods

Whey was obtained from a cheese plant in Erzurum; the fluid whey contained 7.13% dry matter, of which 0.5% was fat, 0.6% was protein, 0.5% was ash and 5.53% was lactose. The beef, from 3-year-old steer, was purchased from a large meat packer in Erzurum, Turkey. The meat was deep frozen ( $-38^{\circ}\text{C}$ ) after wrapping in aluminum foil and was kept for 5 months at  $-20^{\circ}\text{C}$ . Then the beef was ground and the meat proteins were extracted as outlined by Li-Chan et al. [14] with minor modifications. For sarcoplasmic protein extraction, 50 g meat was homogenized with 7 volumes of extraction solution (0.1 M NaCl, 10 mM  $\text{K}_2\text{HPO}_4$  at a pH of 6.6) for 3 min and centrifuged at 3,000 g for 10 min, and then supernatant was removed and kept at  $4^{\circ}\text{C}$  overnight. The supernatant was re-centrifuged twice at 3,000 g, the sediment was removed and the NaCl concentration was adjusted to 0.4 M. To prepare the total muscle proteins (TMP), 50 g meat sample was homogenized for 3 min at 20,000 rpm in a Waring blender jar with 10 volumes of a buffer solution containing 0.4 M NaCl, 10 mM  $\text{K}_2\text{HPO}_4$  at a pH of 6.6. Then the homogenate was filtered through a two-fold cheese cloth to remove cellular debris and connective tissue. After the extraction and purification procedures, the protein concentration and pH of the protein solutions, including fluid whey, were standardized to 5 mg/ml (with the extraction buffer) and 6.6 (either with 1 N NaOH or HCl), respectively. The protein concentration of the samples was determined by using the micro-kjeldahl method. The protein solutions were kept in a laboratory refrigerator at  $4\pm 1^{\circ}\text{C}$  in glass jars throughout the research. The oil used in this study was refined and winterized commercial quality corn oil.

**Emulsion capacity (EC).** EC was determined using a model system described by Ockerman [15] and Zorba et al. [5]. The method utilized for end-point determination has been described by Webb et al. [16]. To measure EC, 30 ml of protein solution (containing 5 mg/ml protein) was placed into a blender (Waring Blender Model 34B199) jar and mixed for about 10 s at 5,000 rpm, and 20 ml corn oil was added to the blender jar. Then the electrodes were placed into the jar and connected to an ohm meter (Huang Chang HC-3010BZ) to detect the break point of the emulsions. The corn oil was added from a burette at a rate of  $\approx 0.7$  ml/s using a blender speed of 13,000 rpm. At break point, which was determined by a sudden increase in resistance, oil addition was stopped and the total amount of oil used was determined. The total amount of oil emulsified included the first 20 ml of oil added and the amount used during the emulsification. EC was reported as millilitres oil emulsified by 150 mg protein.

**Emulsion viscosity (EV).** A newly formed emulsion was used to determine EV, and the process was completed as described by Lopez de Ogaro et al. [17] and Zorba et al. [6]. In this evaluation, approximately 25 g of the emulsion was transferred to a cellulose nitrate test tube and the viscosity value was determined using a Poulten Rotating Viscosimeter (RV-8, Selve and Lee, Wickford, Essex, UK). The evaluation was conducted at  $18\text{--}20^{\circ}\text{C}$  using a No. 5 spindle device at 20 rpm and 50 rpm rotation speeds, and the results were reported as centipoise (cP) units, where  $\text{IP} = 0.1 \text{ Pa}\cdot\text{s}$ .

**Protein solubility determinations.** The protein solubility (%) was determined by the "dye binding method", using bovine serum albumin as the standard [18]. In this procedure, 20 ml of the protein solutions, which had been previously standardized to 5 mg/ml (pH = 6.6) and kept overnight at  $4^{\circ}\text{C}$ , were further diluted to 1 mg/ml using 10 mM phosphate buffer. Then the solutions were centrifuged at 10,000 g for 10 min and the supernatants were analysed for the soluble proteins (%).

**Statistical analysis.** Collected data were subjected to analysis of variance (ANOVA) using a factorial design. Basic statistics and ANOVA were performed to test for the significance of differences within replications and between the treatments [19]. Significant treatment and interaction data were further analysed using Duncan's multiple range tests [20]. In this study, the emulsions were prepared using four different proteins and combinations of them, and, thus, the experimental design was a  $4 \times 5$  completely randomized design.

## Results and discussion

### EC and protein solubility

There were significant differences ( $P < 0.05$ ) between all the proteins studied and their combinations for EC determinations (Table 1). As can be observed from the data, fluid whey had a higher EC than did sarcoplasmic proteins, but a lower EC than the TMP and the combination of whey plus TMP. The TMP had the highest EC among the treatments, as would be expected. However, muscle proteins significantly increased the EC of the whey proteins when they were combined together in a 1:1 ratio. This result might have occurred due to the constructive interactions between the two different animal proteins of different configuration or structure. Hence, we can not manufacture a comminuted meat product without muscle proteins, most of which are myofibrillar proteins and are important for acceptable emulsification [4, 21]. Myofibrillar proteins, which have a thread-like structure, would contribute to the emulsification process by encircling more fat molecules [9], as also seen from the present results (Table 1).

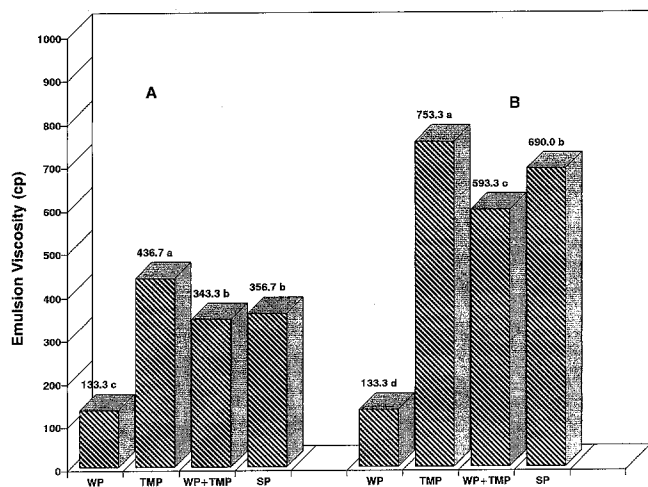
The protein solubility results of the whey and muscle proteins were also significantly different (Table 1). The solubility of the whey proteins was lower than that of sarcoplasmic proteins but higher than that of the TMP and myofibrillar proteins (data not presented), while no discernible differences were measured in a 1:1 (FW: TMP) combination of them both in the buffer. This result is surprising, since the whey was obtained from pasteurized milk (at  $65^{\circ}\text{C}$  for 30 min) in which a decrease in the protein solubility and an increase in the protein hydrophobicity was to be expected [22], which might be why it had a higher EC than did the sarcoplasmic proteins (Table 1). From these results it can be concluded that there would be no negative effect of the whey on the quality of batter-type meat products if fluid whey were to be added to the frankfurter-type recipes.

**Table 1.** Measurements of emulsion capacity and protein solubility of fluid whey, different meat proteins and their combination

Treatments	Parameter			
	Emulsion capacity	$\pm$ SD	Protein solubility	$\pm$ SD
Fluid whey (FW)	79.46 <sup>c</sup>	0.65	84.83 <sup>b</sup>	2.12
Total muscle proteins (TMP)	112.47 <sup>a</sup>	2.40	62.03 <sup>c</sup>	1.27
FW + TMP (1:1)	100.27 <sup>b</sup>	0.75	83.20 <sup>b</sup>	1.39
Sarcoplasmic proteins	59.50 <sup>d</sup>	0.36	98.17 <sup>a</sup>	1.10

Emulsion capacity is expressed in millilitres of oil per 150 mg protein, protein solubility is expressed in milligrams of protein per millilitre of solution

<sup>a-d</sup> Means with the same letters in a column are not significantly different ( $P > 0.05$ )



**Fig. 1A, B.** Raw emulsion viscosity of different meat proteins and whey. **A** 50 rpm rotation, **B** 20 rpm rotation. *WP*, fluid whey protein; *TMP*, total muscle proteins; *SP*, sarcoplasmic proteins. *a-d* Means with the same letters in a bar row are not significantly different ( $P > 0.05$ )

### Emulsion viscosity (EV)

As can be seen in Fig. 1, the EV of the proteins was significantly ( $P < 0.05$ ) different for the various proteins used in this study. For instance, whey proteins had the lowest EV among the proteins studied, when compared to the muscle proteins and their combinations. The reason for this result might be largely due to the structural configuration and solubility (Table 1) of the whey proteins in the buffer solution [23]. In this research, low viscosity results were also determined with sarcoplasmic proteins which have a similar protein structure as far as is known. There was no significant difference between the emulsions of sarcoplasmic protein and TMP plus whey with respect to their viscosity; both were lower when compared to TMP (Fig. 1). EV studies with different proteins and combinations gave almost identical results with either 20 rpm or 50 rpm rotation in the viscosimeter, although their magnitudes differed (Fig. 1).

### Conclusion

The EC and EV of TMP were higher than those of the other proteins investigated, including the combination of whey and TMP. However, the solubility of TMP was lower than that of the other proteins studied, and one possible explanation for this result is the difference in the physico-chemical or structural attributes between whey and muscle proteins. In general, EC of whey showed a significant alteration when in combination with muscle proteins (Table 1), while solubility showed the reverse, indicating an interaction between muscle and whey proteins, that is, the solubility of the muscle proteins increased in the presence of whey. These results might be related to the structure of the meat

and whey proteins which may have interacted well with the muscle proteins.

Although whey protein concentrates have been found to be more suitable in beef replacements of frankfurter-type meat products compared to the dried sweet whey [2], chilled fluid whey might also be used to partially replace cold water or ice chips during the processing of comminuted meat products. Thus, nutritional quality and, to some extent, textural and structural quality of the meat products will be improved. In conclusion, it can be stated that the emulsion quality criteria of whey used in conjunction with muscle tissue should be studied further and comparisons made so as to obtain reliable information for actual meat emulsions. The meat industry uses WPC or dried milk proteins, but not fluid whey, in actual comminuted meat products. Therefore, the studies with different WPC and/or whey fluids with the model and actual meat systems should proceed to accumulate detailed information on this subject.

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