DAIRY PRODUCTS RESEARCH CENTRE

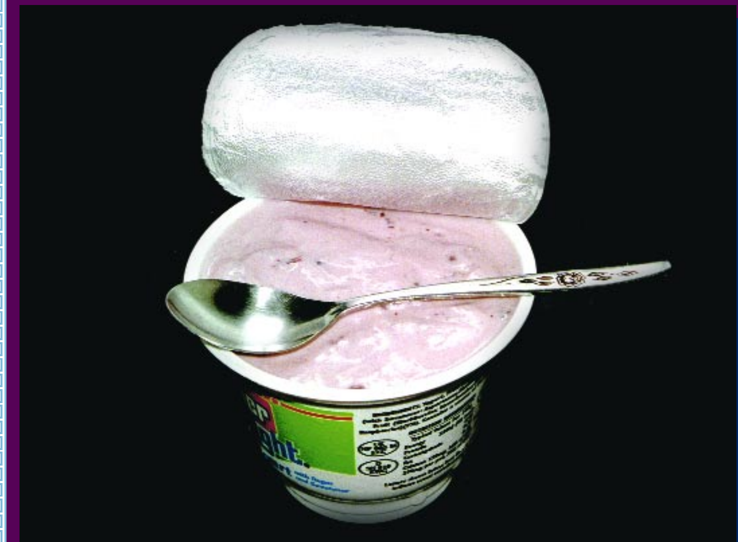
MOOREPARK

END OF PROJECT REPORT 1999: DPRC No. 28

Improving The Quality of Yogurt

Dr. Martin Wilkinson

The viscosity, firmness and stability of yogurt is increased by increasing protein and fat content in the milk and by increasing the ratio of casein to whey protein.



Teagasc

The Science of Farming and Food

Effect of Milk Composition on the Quality of Fresh Fermented Dairy Products
(Improving the Quality of Yogurt)

ARMIS No 4615

Project Team:
M.G. Wilkinson (Leader)
T.P. Guinee
M.A. Fenelon

The Dairy Products Research Centre
Moorepark, Fermoy, Co. Cork.

Teagasc acknowledges with gratitude grant aid under the Food Sub-Programme (Sub-Measure 3 (ii) - Institutional R&D) of the Operational Programme for Industrial Development. The Programme is managed by the Department of Agriculture and Food supported by EU and national funds.

ISBN No. 1 84170 121 1
DPRC No. 28

Teagasc 19 Sandymount Avenue
Ballsbridge Dublin 4

EUROPEAN UNION
European Regional Development Fund

Summary and Conclusions

The rheology of yogurts or fresh fermented products generally describes and measures the texture of the product and includes such terms as viscosity and firmness of the gel while syneresis refers to the tendency of the yogurt to whey-off during storage. The importance of rheology and susceptibility to syneresis of fermented milk products is that they both have major impacts on consumer perceptions of the final product quality. Indeed, variation in the quality of yogurt products can lead the consumer to experience either an over-thin watery or an over-thick stodgy texture or a product which has a high level of free whey. It is obvious that the seasonal milk supply in Ireland compounds the particular difficulties associated with achieving a consistency in the quality of yogurts or other fresh fermented products.

Importantly, both the rheology and syneresis of yogurts are markedly influenced by milk composition, processing treatments and the addition of hydrocolloids. Therefore, this project was undertaken so as to develop a laboratory fermented milks model system which allows the evaluation of the effects of variation of milk components, individually or in combination, on the rheological and syneretic properties of fermented milk products such as yogurt. In particular, the effects of varying total protein, casein-to-whey protein ratio, and fat content were studied as these variations reflect both the differences in milk composition due to lactational/seasonal effects and those due to process variations such as milk heat treatment.

Main Conclusions and Achievements

- Variation in milk composition and the ratio of casein-to-whey protein had major effects on the rheology and syneretic properties of acid gel systems such as yogurt.

- Increasing protein and fat contents in the milks resulted in increased gel firmness and viscosity, while decreasing the ratio of casein-to-whey protein in the milks resulted in increased viscosity, and decreased levels of syneresis. Decreasing this ratio lead to more rapid pH development in the yogurts.

- This study has provided much valuable information on how yogurt systems may be optimised in terms of their composition and process parameters in order to produce a product with consistent optimal texture and a decreased tendency to whey-off during transport and storage.

- A pilot scale trial to produce a Greek-style yogurt for an individual client was successfully undertaken.

Research and Results

The Main Objectives of this Project were

- Development of a laboratory scale model fresh cheese system to evaluate the effects of varying levels of milk components (protein, fat, casein-to-whey protein ratio) on the rheological properties of yogurt.

- Development of various rheological methods to monitor the effects of varying milk compositional parameters on the rheological properties of yogurt.

- Generation of a database of information on the effects of varying milk compositional parameters on the rheological properties of laboratory scale yogurt.

Development of a laboratory scale model fresh fermented product

Model milks for yogurt manufacture were prepared by dispersing phosphocasein, whey protein isolate, and ultrafiltration permeate in de-ionized water.

The advantages of the model system compared to fresh milk, the composition of which changes with season, are that: (1) the concentrations of the different components (e.g. protein, fat, casein and whey protein) can be varied systematically, (2) the ratio of the native whey protein to casein and denatured whey protein can be varied systematically, and (3) it enables a more precise assessment of the concentration of the following on the quality of fresh fermented products such as cultured milks, yogurt and fresh cheeses; fat, protein casein-to-whey protein ratio, different types of whey proteins. The blend was then sheared under defined conditions. In this way the composition of the milks for yogurt manufacture could be altered by varying concentrations of its various components so as to mimic the effects of seasonal changes in milk composition and varying heat treatments during processing.

Table 1. Typical composition of the model milks used for manufacture of yogurts

Ingredient	Parameter range (%) w/w
Casein	2.7
Whey protein	1.8
Fat	0.37
Lactose	4.7

The resultant milks were stored overnight at 4°C, and homogenised at first and second stage pressures of 150 and 50 and Kgf/cm^2, respectively. The homogenised milks were then

heated in a plate heat exchanger (APV Pasilac SSP pilot plant; APV, Denmark) at 90°C for 5 min, and then cooled to 42°C. The milks were inoculated with a 1:1 mix of *Streptococcus thermophilus* (TH4) and *Lactobacillus bulgaricus* (LB12); both cultures were obtained from Chr. Hansen, Little Island Industrial Estate, Cork, Ireland. Acidification was allowed to continue until a pH of 4.6 was reached after which the yogurt gels were cooled to less than 10°C.

Rheological measurement and pH development of fermented milks

The rheological properties of the resultant fermented milks were monitored using low amplitude strain oscillation rheometry (Carri Med CSL^2 500) by measuring: (i) gel firmness as the elastic shear modulus (G') as a function of strain, and (ii) viscosity as a function of shear stress and shear rate. The stress/shear rate can be used to obtain an objective measurement of product thickness and susceptibility to shear. The susceptibility to syneresis was measured by subjecting the yogurts to centrifugation at 1230, and 2460 g-force.

The effect of varying casein-to-whey protein ratio on the development of pH in the model yogurt systems was measured in a CINAC multi-probe system which carries out a series of pH measurements over a 7-hour incubation period.

Effects of varying protein and fat levels and casein-to-whey protein ratios on the rheology and syneresis of yogurts

(a) Protein content

Increasing the protein content within the range 3.5 to 5.5% w/w, while maintaining the fat content constant at 0.37% w/w, resulted in linear increases in G' and apparent viscosity, and reductions in fracture strain. *(Figs 1 and 2)*.

The increase in gel strength and apparent viscosity with increasing protein content probably ensues from the higher level of available gel forming protein. The results indicate that seasonal variations in protein level are likely to have an effect on the gelation properties of milk intended for the production of acidified products such as yogurt.

Fig. 1. The elastic shear modulus as a function of strain for fermented milks of different protein content: 3.5% (□), 4.0% (▫), 4.5% (○), 5.0% (▫), and 5.5% (■) w/w protein (the casein-to-whey protein ratio was 60:40 while the fat content was 0.37% in all milks).

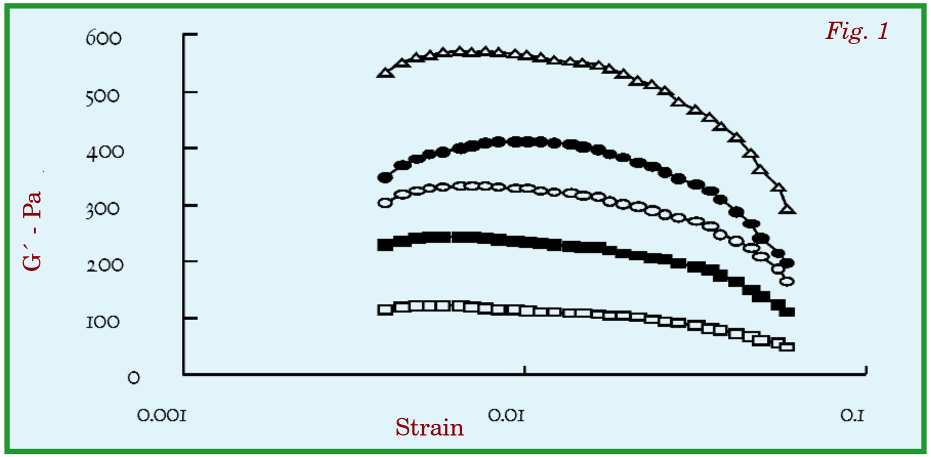
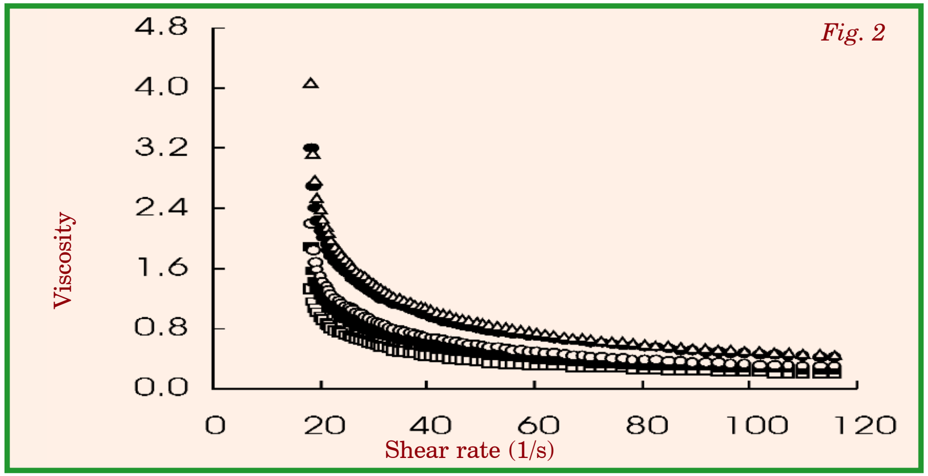


Fig. 2. Viscosity-shear rate plots of fermented milks with different protein content: 3.5% (□), 4.0% (▫), 4.5% (○), 5.0% (▫), and 5.5% (■) w/w protein (the casein-to-whey protein ratio was 60:40 while the fat content was 0.37% in all milks).



(b) Ratio of Casein to Whey Protein

Altering the casein:whey protein from 100:0 to 60:40 while maintaining the protein content constant at 4.5% resulted in marked increases in G´ and viscosity *(Figs. 3 and 4)*. Whey proteins are denatured during heating and interact with the casein micelles to enhance the acid gel forming properties of milk. This effect is due to the formation of a finer gel network that is less susceptible to deformation and also has less tendency to synerese.

The results of this study indicate that decreasing the ratio of casein:whey protein may have a similar effect on acid gel strength as increasing the total protein content. This is an important consideration for manufacturers when choosing ingredients for inclusion in a formulation for fresh cheese products.

Fig. 3. The elastic shear modulus as a function of strain for fermented milks of different casein-to-whey protein ratios: 60:40 (□), 70:30 (▫), 80:20 (○), 90:10 (▫), and 100:0 (■) (the total protein content was 4.5% while the fat content was 0.37% in all milks).

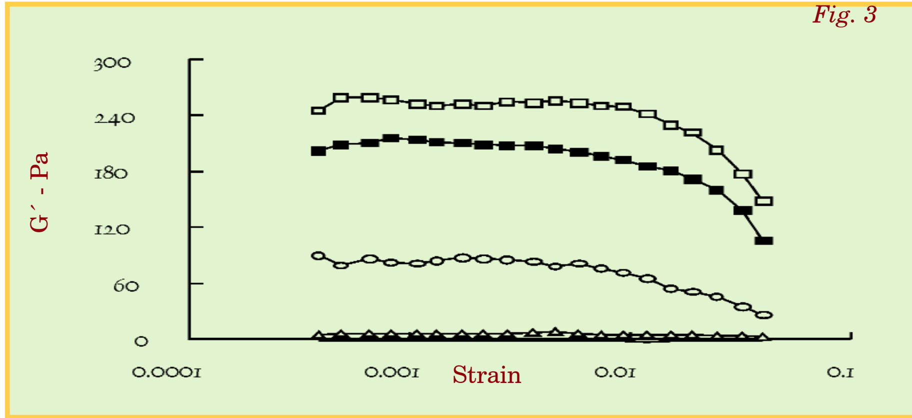
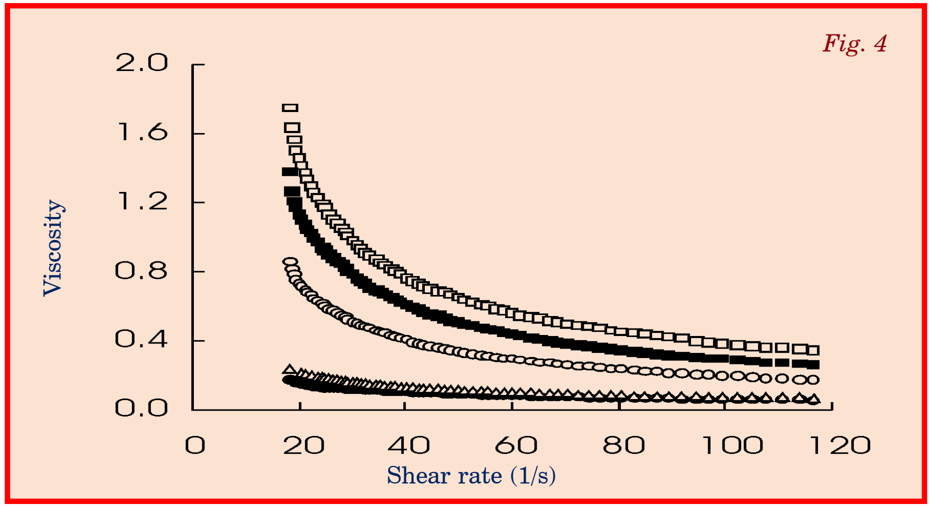


Fig. 4. Viscosity-shear rate plots of fermented milks with different casein-to-whey protein ratios: 60:40 (□), 70:30 (▫), 80:20 (○), 90:10 (▫), and 100:0 (■) (the total protein content was 4.5% while the fat content was 0.37% in all milks).

Decreasing the casein:whey protein resulted in a marked increase in the rate of pH decline



with time *(Fig. 5)*. This effect was due to a reduction in the proportion of casein, which is the principle buffering agent in milk, as a % of total protein. Another important finding was that the level of syneresis was substantially reduced in yogurts made with milks which were formulated to contain a low ratio of casein-to-whey protein *(Fig. 6)* - an effect which may be attributed to the possible finer gel network present in the milks with higher levels of whey protein present.

Fig. 5. Development of pH in model fermented milks made with different casein-to-whey protein ratios: 60:40 (▫), 70:30 (□), 80:20 (▫), 90:10 (○), and 100:0 (▼) (the total protein content was 4.5% while the fat content was 0.37% in all milks).

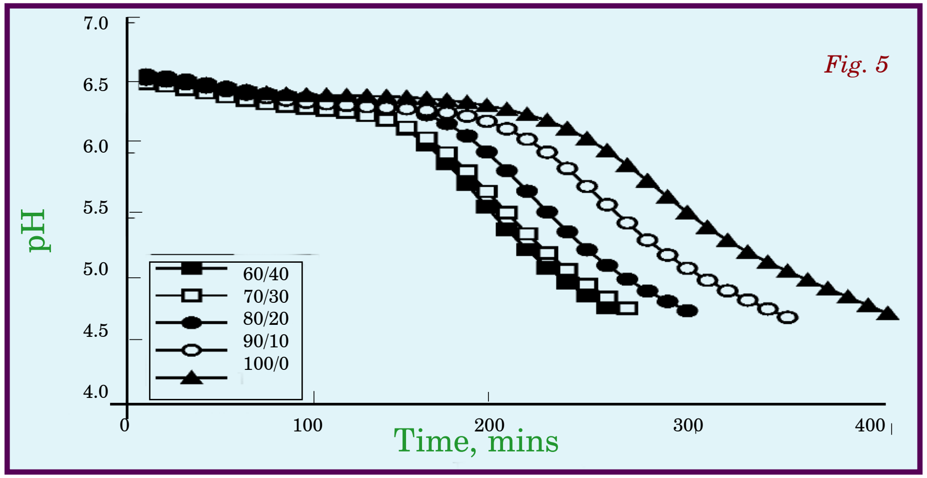
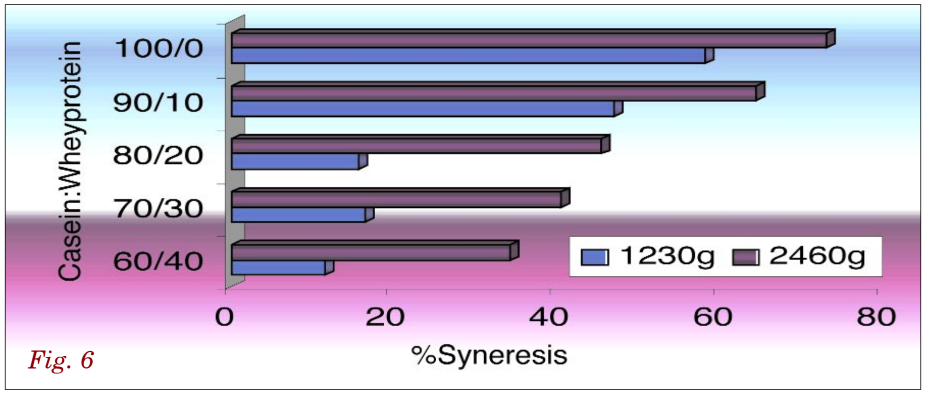


Fig. 6. Effect of different casein-to-whey protein ratios: 60:40, 70:30, 80:20, 90:10, and 100:0 on the susceptibility of fermented milks to syneresis measured at 1230 or 2460g (the total protein content was 4.5% while the fat content was 0.37% in all milks).



(c) Fat Content

Increasing fat content within the range 0.37 to 4%, while maintaining the protein constant, resulted in increases in G´ and apparent viscosity *(Figs. 7 and 8)*.

Fig. 7. The elastic shear modulus as a function of strain for fermented milks of different fat content: 0.37% (□), 1% (▫), 2% (○), 3% (▫), and 4% (■) w/w fat (the total protein content was 4.5% while the casein-to-whey protein ratio was 60:40 in all milks).

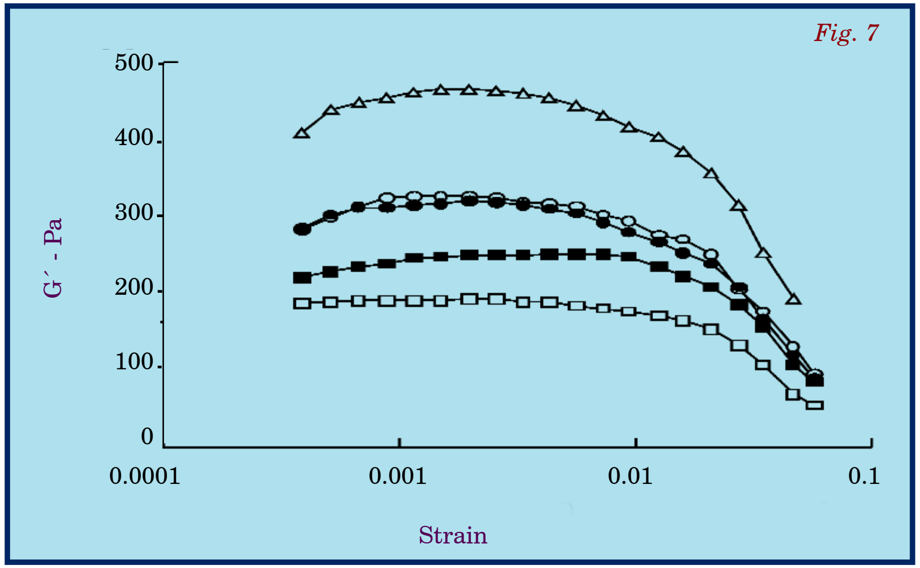
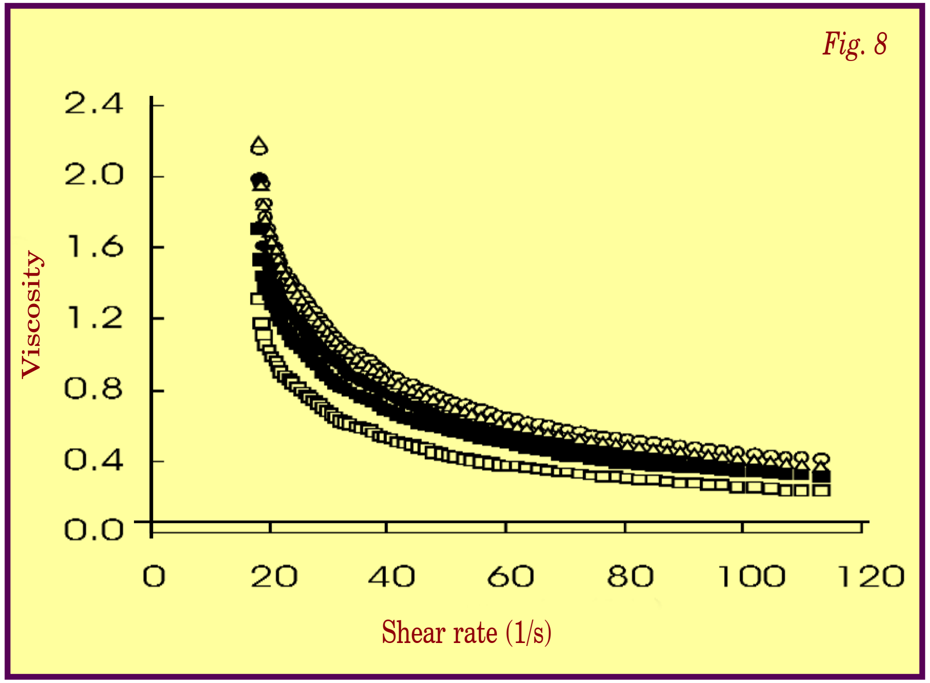


Fig. 8. Viscosity-shear rate plots of fermented milks with different fat content: 0.37% (□), 1% (▫), 2% (○), 3% (▫), and 4% (■) w/w fat (the total protein content was 4.5% while the casein-to-whey protein ratio was 60:40 in all milks).



Publications

Fenelon, M.A., Guinee, T.P., Kelly, P.M., O'Kennedy, B.T. and Wilkiinson, M.G. (2000). The effect of total protein, casein:whey protein ratio and fat content on the rheological and syneretic properties of yogurts. *Irish J. of Agric. and Food Res.* 39:171.

For further information, please contact Dr Tim Guinee

Dr. M. Wilkinson

Dr. M. Fenelon

DAIRY PRODUCTS RESEARCH CENTRE
Moorepark, Fermoy, Co. Cork, Ireland
Tel: +353 (0) 25 42222 - Fax: +353 (0) 42340
E-mail: reception@moorepark.teagasc.ie