Possibilities of yolk rheological measurements to characterise egg origin and processing properties

Amanda Laca, Benjamín Paredes and Mario Díaz*
Department of Chemical Engineering. University of Oviedo
C/ Julian Claveria s/n. 33071 Oviedo, Spain

Posibles usos de medidas reológicas en la caracterización del origen y las propiedades de procesado del huevo

Possibles usos de mesures reològiques en la caracterització de l'origen i les propietats de processament de l'ou

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RESUMEN

Yemas de huevos procedentes de diferentes aves de corral y de gallinas alimentadas de modo distinto han sido analizadas mediante el empleo de medidas reológicas y de termocalorimetría diferencial. Los resultados mostraron que las medidas reológicas de yema pueden resultar útiles para determinar la especie de procedencia del huevo, mientras que la termocalorimetría diferencial podría permitir diferenciar huevos procedentes de gallinas alimentadas con diferentes dietas.

Palabras clave: reología, DSC, ave de corral, omega-3, yema.

SUMMARY

Egg yolk samples coming from different fowl species and differently fed hens, have been analysed using rheological measurements and differential scanning calorimetry. Results showed that rheological measurements could be useful to determine differences between different fowl species, while differential scanning calorimetry could be suitable to evaluate differently fed hen eggs.

Keywords: rheology, DSC, fowl, omega-3, yolk.

RESUM

S'analitzen rovells d'ous procedents de diferents aus de corral i de gallines alimentades de forma diferent mitjançant la utilització de mesures reològiques i de termocalorimetria diferencial. Els resultats mostren que les mesures reològiques del rovell poden resultar útils per determinar l'espècie de la que procedeix l'ou, mentre que la termocalorimetria diferencial podria permetre diferenciar ous procedents de gallines alimentades amb diferents dietes.

Mots clau: reologia, DSC, au de corral, omega-3, rovell.

***Corresponding author:** mariodiaz@uniovi.es

INTRODUCTION

Hen egg is considered nature's most complete food. Containing high quality proteins, it has a ratio of 2-1 unsaturated to saturated fats content and is a source of iron, phosphorus and other minerals. Besides, it contains all the vitamins except for vitamin C. Today consumers can find different types of eggs, due to the fact that in different parts of the world nutritional enhanced eggs or designer eggs (omega eggs, organic eggs, free-range eggs, vegetarian eggs, etc.) are supplied to the market. These new types of special eggs may be slightly different in nutrient value to that of regular eggs, or they may come from hens housed or fed in a special way[1].

Egg yolk represents about 30% of the fresh whole egg weight and contains < 50% solids; the major constituents of the solid matter are lipids (< 70% on dry basis) and proteins (< 30% on dry basis)[2]. In addition to its nutritional properties, hen egg yolk is an ingredient that brings together different functional properties of much importance in food industry, such as emulsifying or gelling properties[3]. Egg yolk composition and physical structure is highly dependent on several factors, in fact diet has a great influence on yolk characteristics[2].

The aim of this work was to obtain a first approximation to the possibilities of yolk rheological and differential scanning calorimetry measurements in order to characterise egg origin and its properties. These studies concerned, on the one hand, the possible identification of eggs coming from different fowl species and, on the other hand, the influence of feeding on yolk processing properties.

MATERIAL AND METHODS

Birds and diets. The birds employed in this work were: Leghorn hen (*Gallus domesticus*), domestic duck (*Anas domesticus*) and guinea fowl (*Numida meleagris*). These species were chosen due to the fact that they are usually used as typical laying fowls in egg production farms. In order to evaluate the effect of the specie, all fowls were fed with a standard diet for laying hens (17% crude protein, 14% crude ash, 5% crude fat, 3% crude cellulose and 0.35% methionine) and they were free-range. In the study of feeding effect, the fowl used was Leghorn hen, as it is the typical breed used in the commercial egg farms. Hens were caged and control hens were fed with a standard diet (16% crude protein, 15% crude ash, 3% crude fat, 4% crude cellulose and 0.35% methionine) while omega-3 hens were fed with a high unsaturated acids content diet (feed was supplemented with fish oil).

Sample preparation. The shelling of the eggs and the separation of the yolk from the albumen were performed manually. The albumen residuals were eliminated from the yolk using a blotting paper, and the removal of the vitelline membrane was achieved using tweezers. For the different analyses developed, the yolks were manually mixed with a spatula.

Analyses. The total lipids content was evaluated following the extraction by acid hydrolysis method4. The Kjeldahl method of nitrogen analysis was carried out for calculating the protein content. Analyses were performed in triplicate.

Rheological measurements. The rheological tests were developed with a Haake RS50 RheoStress rotational rheometer with a plate/plate measuring system (PP60), a gap of 1mm and the sample amount of about 2.9 g.

In steady state, flow curves were carried out in CS mode at 5±1°C from 0 to 500 Pa of shear stress during 300s. It is well know that egg yolk shows a pseudoplastic behaviour[4,5] , so the data obtained from the flow curves were fitted to the Power Law equation (1) and the values of their behaviour index (n) and consistency index (K) were determined. In the equation (1) τ is the shear stress (Pa) and $\dot{\gamma}$ the shear rate (s^{-1}).

$$\tau = K.\dot{\gamma}^{n} \quad (1)$$

All data were fit using the Haake Rheowin Software. At least 10 samples of each fowl specie were analysed. Data were analysed running t-tests to compare means, at a 5% probability level. Previously F-tests at a 5% probability level were developed to compare standard deviations. In case the data presented heterogeneity, they were statistically homogenized. The standardized skewness and standardized kurtosis were used to know that the samples came from normal distributions. The software used was STATGRAPHICS Plus 3.1.

The dynamic tests ("cure tests") were performed in the linear vicoelasticity range that was previously established. The frequency employed was 1Hz, the temperature ramp went from 5°C to 80°C at a heating rate of 0.6 °C/min and they were carried out in CS mode at a constant shear stress of 10 Pa. Since different studies[7,8] assess that the gel point occurs at the time at which G' (storage modulus) and G" (loss modulus) cross each other at given frequency, in this work the gel point was detected in this way using the Haake Rheowin Software. Analyses were developed in triplicate.

Differential scanning calorimetry (DSC). The DSC tests were carried out in aluminium pans hermetically sealed, in a DSC 822e equipment, developing temperature ramps from 5°C to 80°C at a heating rate of 0.6 °C/min in a nitrogen atmosphere. The heating rate was the same as the employed in the cure test due to the fact that the gelling temperature is strongly influenced by the temperature ramp[9]. As a well pronounced endothermic peak coincides with the moment of coagulation[8], the coagulation temperature of the samples was determined in this way. Analyses were performed in duplicate.

RESULTS AND DISCUSSION

The characteristic values of n and K for the studied fowls are shown in table 1. All the flow curves data obtained a value of R^2 at least of 0.9990 for the fitted equation (1). As can be seen, t-tests showed not significant differences in n value between domestic duck and Leghorn hen, while K value was significantly different for all studied species (confidence interval of 95%). Thus, rheological measurements could allow determining differences between different fowl species according to K index value, providing that all the measurements are carried out in the same conditions.

Table 1. *Values of the behaviour index (n) and the consistency index (K) of egg yolks obtained from different fowl species. There are reported the average values ± SD*

	n (dimensionless)	K (Pa.s^n)
Leghorn hen (*Gallus domesticus*)	0.688±0.022a	9.7±3.2a
Domestic duck (*Anas domesticus*)	0.705±0.021a	15.1±2.4b
Guinea fowl (*Numida meleagris*)	0.603±0.024b	42.5±7.5c

$^{a, b, c}$ Values within the same column with no common superscript are different. Confidence interval of 95%

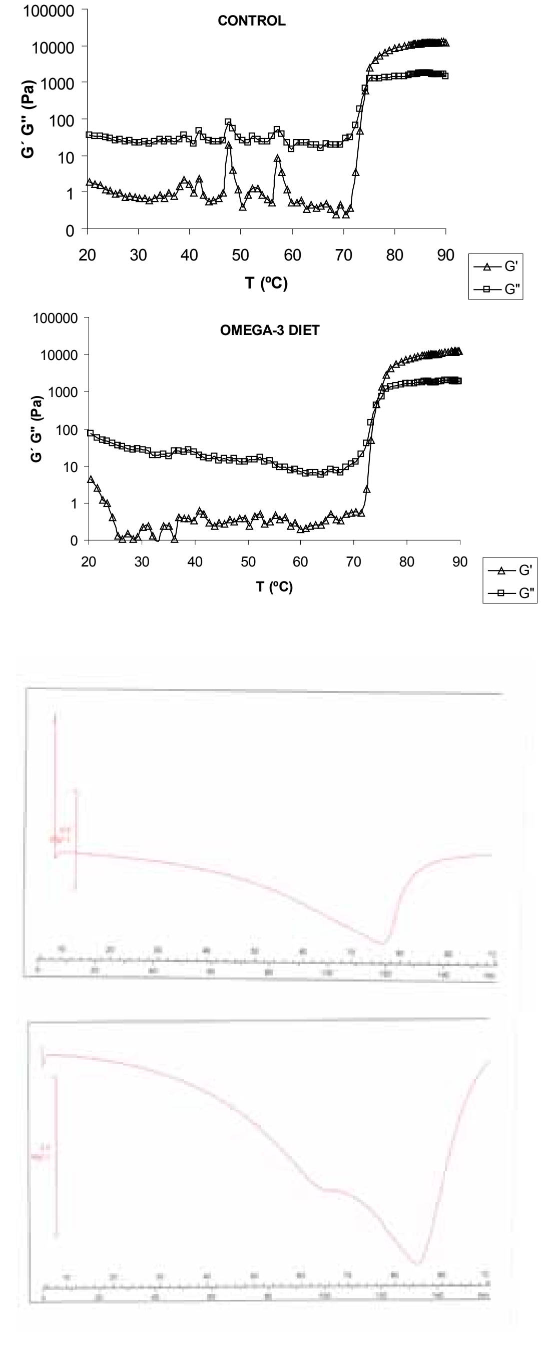

Figure 1. *Cure tests (top) and DSC analysis (bottom) for egg yolks coming from Leghorn hens with a control (up) and omega-3 diet (down)*

During gelation, yolk undergoes a phase transition from a liquid to a gel. The sol-gel transition is a critical point where the transition variable would be related to the yolk chemical composition[7]. Yolk coagulation kinetics was analysed using dynamic tests and DSC analysis, results are shown in figure 1. The values of the gel point temperature obtained from the cure tests were 74ºC for the control and 75ºC for the omega-3 diet, while the coagulation temperature obtained from the DSC were 78ºC for the control and at 85ºC for the omega-3 diet. There were no great differences between the values of the gel point temperature obtained for hens differently fed. However DSC analyses showed a coagulation temperature quite different for hens differently fed, being higher for the omega-3 diet.

The amount of protein content in yolk was 16.9% for the control and 17.1% for the omega-3 diet, while the proportion of lipids was 32.3% for the control and 34.5% for the omega-3 diet. So the amount of protein content in yolk is very similar for the control and for the omega-3 diet, while the proportion of lipids is different, being higher for the omega-3 diet. These different lipid proportions of the yolk may be responsible of the different coagulation temperatures detected by the DSC analyses.

CONCLUSION

Rheological measurements could be useful to determine egg origin according to the yolk K index value for specific conditions of analyses. Additionally DSC measurements seem to be more useful than rheological tests to detect differences in yolk coagulation temperatures and, hence, in the studied different ways of feeding the hens.

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