Storage stability of an egg yolk cream formulation: texture and microbiological assessment

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Abstract

BACKGROUND: Egg yolk cream is confectioned with egg yolk, sugar and water. Pasteurized liquid eggs may be used in order to increase product safety, although these samples may differ from the classic ones produced with raw eggs. The objective was to evaluate and compare the stability (physicochemical characteristics, such as texture assessment, pH and water activity, and microbiological assessment) of a classic formulation and an alternative one produced with pasteurized eggs, during storage at 6, 26, 30 and 37 °C.

RESULTS: From a microbiological point of view (mesophile and psychrotrophic activity), no differences were observed in either formulations. At 6 and 26 °C, rheological behaviour of both formulations remained approximately constant. At 30 and 37 °C, differences were only detected after 20 days of storage. Texture was better retained in samples prepared with pasteurized eggs, while the classic samples showed an increase in complex viscosity.

CONCLUSION: Cream storage did not require refrigeration. In terms of texture and microbial load, results obtained at 6 and 26 °C were identical. The formulations only differed in texture when stored at 30 and 37 °C and for long periods. These conclusions may allow reduction of costs related to refrigerated distribution/storage of either classic or alternative formulations.

Introduction

Egg yolk cream is obtained through the mixture of uncooked egg yolk with a syrup of fine white sugar (sucrose), submitted to a few minutes of soft heating. This sweet is often used in pastry fillings and toppings, as the basis of different fruit and nut custards, or can be simply consumed as a dessert.

To provide the typical colour, aroma, smoothness, structure and consistency, the added egg yolk must be uncooked. However, product safety can be put at risk since foodborne disease outbreaks may be associated with uncooked raw eggs.[1] The use of pasteurized eggs may circumvent this risk. However, changes in food product composition may drastically modify specific characteristics and behaviour during storage. Therefore, studies on products' microbial contamination/spoilage and on quality alterations that might be perceived by consumers are important for development of new formulations.

The high sugar and protein content of egg yolk cream makes it a highly nutritious product but allows the growth of a wide range of microorganisms, such as mesophiles and psychrotrophics, which may contribute to quality losses during storage.

Storage temperature is a major environmental factor responsible for food quality alterations, namely in microbial activity and in texture and nutrition attributes.[2,3] Water activity is another critical parameter influencing the stability of food products. It affects microorganism viability/growth and reaction rates of food quality factors, which may suffer degradation.[2,4–6] Since it mainly affects molecular mobility, water activity may also contribute to changes in physical properties[7] such as crystallization[8] and viscosity.[9,10] These changes in physical properties may significantly affect the perceived texture of a food product. In the particular case of egg yolk cream, texture is one important characteristic that determines consumers' acceptance and product shelf-life. Although it is not possible to quantify human perception using a single mechanical tool, texture can be assessed using results from both rheological experiments and food microstructure analysis.[11–13]

Microbial growth is also significantly affected by pH.[3] Changes in pH may also influence the charge

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of amino acid side chains in high protein content products, thus influencing physical properties of egg-based foods.[14,15]

The objective of this work was to evaluate and compare the stability of a classic egg yolk cream formulation and an alternative one produced with pasteurized eggs, during storage at different temperatures. The assessment was attained by texture and microbiological activity evaluation throughout the storage period. Intrinsic physicochemical parameters, such as pH and water activity, were also studied.

Material and Methods

Sample preparation

The egg cream samples used in this study were prepared following a classic recipe. Thus, 240 g white sugar and 125 mL water were heated until formation of a syrup with specific characteristics (maximum temperature approximately 105 °C).[16]

For the classic formulation (CF), the yellow and white parts of the eggs were separated by hand, and a volume of 220 mL egg yolk was incorporated into the syrup. Raw shell eggs (acquired from a local supermarket) were used.

In the alternative egg yolk cream formulation (AF), the volume of egg yolk was replaced by pasteurized liquid eggs (Derovo, Pombal, Portugal), with pasteurized yolk and white parts in the proportion 80:20% (v/v). This formulation, previously developed and conveniently tested, presents a rheological behaviour similar to the classic egg yolk cream (results not shown). The egg white part was added as a bulking agent.

In both classic and alternative formulations, total egg content was maintained constant. For each formulation, two different batches were prepared. Samples were stored at four different temperatures (6, 26, 30 and 37 °C) during a total of 59 days. The chosen temperatures were representative of refrigerated conditions, room temperature and levels of temperature abuse that may occur in products during the distribution chain. For microbiological analysis, samples were stored in individual sterilized sealed plastic bags. For the remaining analysis, samples were kept in a food-grade aluminium container (Makro, Carnaxide, Portugal).

Water activity and pH

Water activity of egg yolk cream formulations was measured (in duplicate) every 7 days during the whole period of storage, using a dew point hygrometer (Aqualab Series 3, Decagon Devices Inc., Pullman, WA, USA) at 25 ± 1 °C. Calibration was previously carried out with distilled water and saturated saline solutions.

Sample pH was measured (in triplicate) after preparation and at the end of 59 days of storage. A pH meter (GLP 22, Crison, Barcelona, Spain) was used.

Texture assessment

Indirect texture assessment was performed using both rheological studies and microstructure observations.

Rheological behaviour of samples was determined every 7 days during storage, at all temperatures. A controlled stress rheometer Bohlin VOR (Bohlin Instruments Ltd, Cirencester, UK) at 25 °C, with a 20 mm parallel plate configuration, was used. Owing to the large particle size, the gap was set to 2 mm. In accordance with a previous creep test, 2 min delay was given to allow shear history relaxation and to reconfigure the initial state. All measurements were made in the viscoelastic region (strain was 1×10^{-3}, according to preliminary strain sweep tests). Dynamic rheological properties were investigated by applying oscillatory dynamic testing and by measuring complex viscosity. This frequency sweep test was performed in the 0.1–10 Hz range. Dynamic measurements were replicated at least six times.

Sample microstructure was observed at days 0, 21 and 59 of storage, at all temperatures. A light microscope (CX40, Olympus, Tokyo, Japan) with a 40× magnification was used. Images (at least four) of different sections were observed using phase contrast and recorded using a digital camera (DP10; N/S: 8L 13 329, Olympus). No previous sample preparation was required; i.e., a small amount of sample was placed directly on a slide without any dilution or any chemical treatment.

Microbiological assessment

Microbiological assessment was made by enumeration of total plate count of mesophiles and psychrotrophics (ISO 4833: 1991).

Data analysis

All statistical analyses were performed using packages of STATISTICA© 6.0 (StatSoft, Tulsa, OK, USA) and Excel® 2000 (Microsoft, Redmond, WA, USA) software.

Results and Discussion

Water activity and pH

Results from water activity measurements (a_w) are shown in Fig. 1. Samples presented initial water activity values around 0.852 ± 0.003 (± standard deviation). If the egg yolk cream samples were stored at lower temperatures (6 and 26 °C), the water activity values of both formulations remained approximately constant during storage. At higher temperatures (30 and 37 °C), a slight decrease in water activity values was observed for both formulations throughout storage. However, the variation did not exceed 10% of the initial value (corresponding to the alternative formulation, stored for 55 days at the highest temperature) and was not considered relevant.

Results from pH measurements are included in Table 1. The effect of both formulation and 59 days storage temperature were significant (two-way

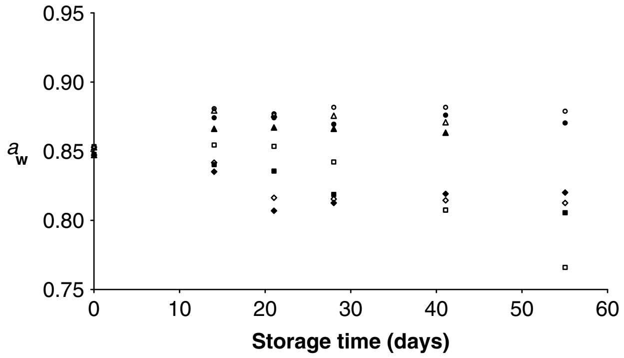

Figure 1. Water activity values of classic (CF) and alternative (AF) egg yolk cream formulations, during storage at different temperatures: ■ 37 °C, CF; □ 37 °C, AF; ♦ 30 °C, CF; ◊ 30 °C, AF; ▲ 26 °C, CF; △26 °C, AF; ● 6 °C, CF; ○ 6 °C, AF.

ANOVA; $P < 0.05$). Classic formulations presented lower pH values than the alternative one (averaging 6.50 and 7.20, respectively). This can be explained by the egg white part addition, which is more alkaline than egg yolk.[15,17] However, the observed differences may not be relevant for influencing microorganism growth and cream textural properties.[14,18,19]

Texture assessment

Rheological determinations revealed viscoelastic behaviour of both egg yolk cream formulations, with samples independent frequency behaviour (results not shown). Changes on rheological behaviour of classic and alternative formulations, during storage at different temperatures, were compared on the basis of complex viscosity, since it reflects simultaneously elastic and viscous components.[20]

Results of complex viscosity, evaluated at 8 Hz, are presented in Fig. 2. It is possible to observe that storage temperature influenced the behaviour of samples. Complex viscosity of samples stored at lower temperatures (6 and 26 °C; Fig. 2(b)) remained approximately constant during 59 days of storage (∼100 Pa s). Such behaviour was observed in both formulations; i.e., the stability of egg yolk cream stored at such temperatures was similar for both classic and alternative formulations.

In samples stored at higher temperatures (30 and 37 °C; Fig. 2(a)) rheological behaviour changed during storage, and differences between formulations were detected. In classic egg yolk cream, complex viscosity increased after 20 days of storage (from ∼50–100 to a maximum of 1000 Pa s). In samples of the alternative formulation such an increase was not so evident and occurred some days later. These observations may indicate that egg yolk cream produced with pasteurized eggs is more stable than that produced with raw eggs, if stored at higher temperatures. This fact can be related to previous studies that report a significant change in protein and lipoprotein content during the pasteurization process of eggs.[21−25] The differences observed in rheological behaviour may also be related to microstructure changes. Microscope images revealed that if samples of both formulations were stored at lower temperatures (6 and 26 °C) no distinct structures were observed. This is in agreement with the water activity and rheological experimental results previously discussed (i.e., no significant changes in these factors were observed at 6 and 26 °C; $P < 0.05$). If samples were stored at higher temperatures (30 and 37 °C), differences between formulations were detected. Classic formulated samples showed crystal formation, whereas non-distinctive structures were identified in samples produced with pasteurized eggs. Figure 3 includes, as an example of the results obtained,

Table 1. Experimental pH values (average ± standard deviation) of the classic (CF) and alternative formulations (AF) stored at different temperatures

		pH after 59 days of storage			
Formulation	pH initial	6 °C	26 °C	30 °C	37 °C
CF	6.58 ± 0.03	6.52 ± 0.05	6.55 ± 0.03	6.49 ± 0.03	6.43 ± 0.03
AF	7.11 ± 0.04	7.30 ± 0.04	7.25 ± 0.05	7.14 ± 0.08	6.99 ± 0.02

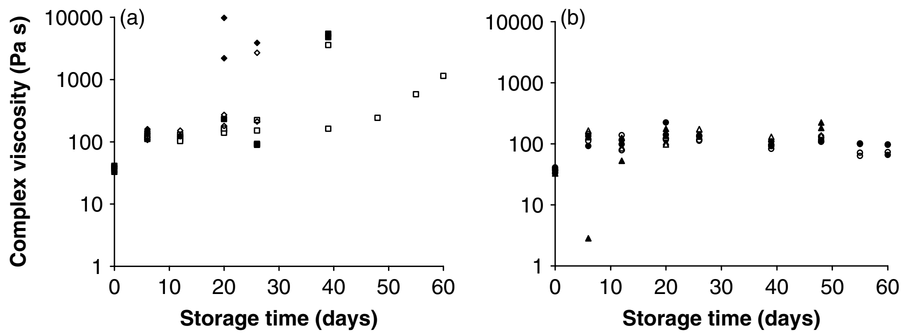

Figure 2. Dynamic behaviour of classic (CF) and alternative (AF) egg yolk cream formulations, during storage at different temperatures (average values of complex viscosity at the frequency of 8 Hz): (a) 37 and 30 °C; (b) 26 and 6 °C. ■ 37 °C, CF; □ 37 °C, AF; ♦ 30 °C, CF; ◊ 30 °C, AF; ▲ 26 °C, CF; △ 26 °C, AF; ● 6 °C, CF; ○ 6 °C, AF.

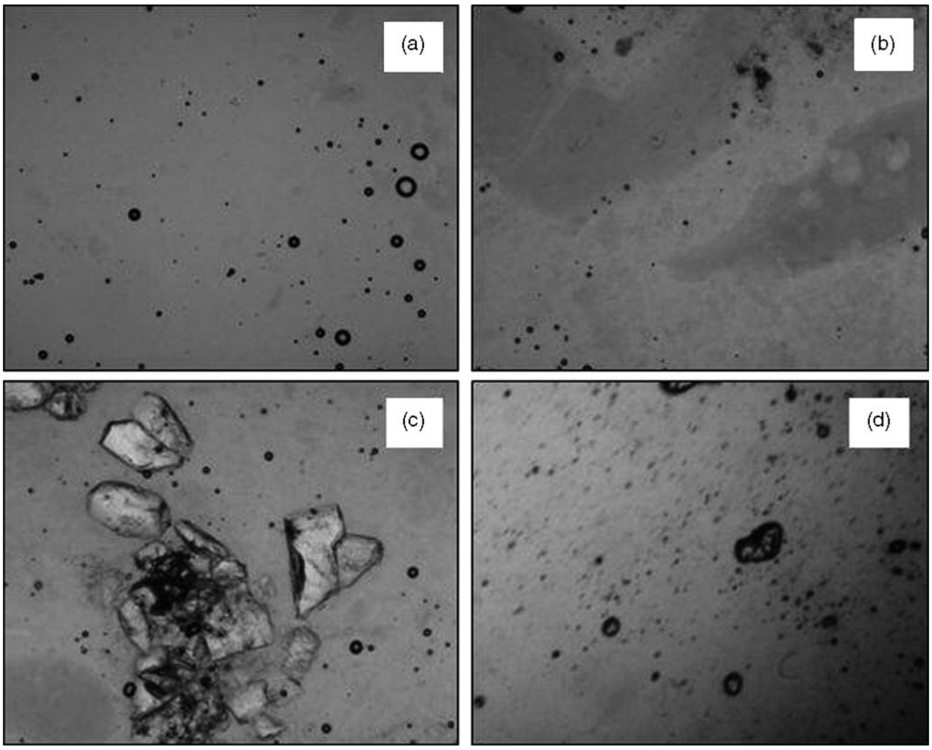

Figure 3. Photomicrographs (40×) of classic (CF) and alternative (AF) egg yolk cream formulations after 21 days' storage at 6 and 30 °C. (a) 6 °C, CF; (b) 6 °C, AF; (c) 30 °C, CF; (d) 30 °C, AF.

microscopic images of CF and AF formulations, after 21 days of storage at 6 and 30 °C.

The crystals observed in CF stored at high temperatures (Fig. 3(c)) may affect the rheological and organoleptic properties of foods,[8] and may contribute to the complex viscosity increase after 20 days of storage (Fig. 2(a)). However, the decrease in water activity values (Fig. 1) is not consistent with crystal formation, which is responsible for water redistribution in a food product.[8] Such a decrease in water activity may be a consequence of water evaporation (since the containers used for storage were closed but not sealed), thus explaining changes in AF rheological behaviour when stored at higher temperatures, where no crystal growth was observed.

Microbiological assessment

Total mesophiles were enumerated in samples stored at all temperatures (6, 26, 30 and 37 °C). Samples' initial microbial load was around 10^2–10^3 CFU g^{-1} (Fig. 4). For egg yolk cream formulations stored at 6 and 26 °C no microbial growth was observed, the mesophile content remaining approximately constant during the whole length of storage (Figs 4(c, d)). This is not surprising for storage at 6 °C, where no growth of mesophiles is expected to occur. However, in samples stored at 26 °C mesophile growth would be expected (total mesophile enumeration includes all microorganisms able to grow in the temperature range 10–45 °C, with an optimum at 35 °C).[3] Microbial competition/antagonism effects[26,27] may explain the results.

With respect to storage temperatures of 30 and 37 °C (Figs 4(a, b)) high variability in microbial enumeration was observed. The number of viable cells varied from ~10^2–10^3 CFU g^{-1} to a maximum of 10^9 CFU g^{-1}, with no particular tendency. This occurred in samples of both formulations. As previously mentioned, total mesophile enumeration includes a large number of microorganisms, with different temperature sensitivities, which justifies the variability of the results. In the case of AF samples, this may also be explained by the pasteurization process of the eggs used. The liquid eggs do not present the same microbial profile, since pasteurization can only assure the inactivation of a target microorganism (*Salmonella* sp. is the relevant one).[28]

For samples stored at 6 °C, total psychrotrophics were enumerated. However, these microorganisms were not present in samples of both formulations, during the whole storage period.

Conclusions

The classic egg yolk cream and alternative formulation with pasteurized eggs were similar in terms of microbial load, during 59 days of storage at 6, 26, 30 and 37 °C. This indicates that, from a microbiological quality point of view, both formulations are identical. However, if egg yolk cream is produced with pasteurized eggs, the absence of *Salmonella* sp. is guaranteed and the product can be considered safer.

The temperature effect was evident. If the cream is stored at 6 and 26 °C, no mesophile growth was detected in either formulation. At 30 and 37 °C a high

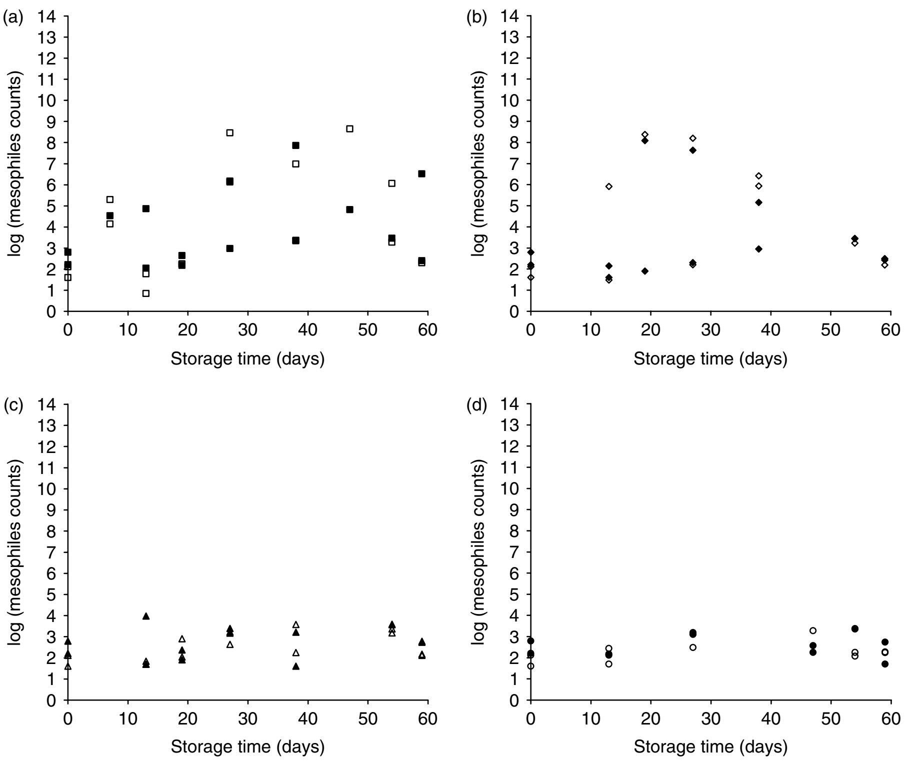

Figure 4. Mesophiles enumeration in classic (CF) and alternative (AF) egg yolk cream formulations, during storage at different temperatures: (a) 37 °C; (b) 30 °C; (c) 26 °C; (d) 6 °C. ■ 37 °C, CF; □ 37 °C, AF; ♦ 30 °C, CF; ◇ 30 °C, AF; ▲ 26 °C, CF; △ 26 °C, AF; ● 6 °C, CF; ○ 6 °C, AF.

variability in mesophile load was observed throughout storage, and a considerable increase in number of microorganisms was observed.

From a quality point of view, the formulations only differ in texture when stored at 30 and 37 °C and for long periods of storage (over 20 days). Texture was better retained in samples prepared with pasteurized eggs.

Overall it can be concluded that refrigeration is not necessary in egg yolk cream storage (if abuses do not occur). Results in terms of texture and microbial load were identical to those obtained at 26 °C. This conclusion may allow reducing costs related to a refrigerated distribution/storage of either classic or alternative egg yolk cream formulations.

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