

Influence of storage temperature on the texture profile and colour characteristics of UHT *Requeijão cremoso*

Influência da temperatura de estocagem no perfil de textura e na cor do requeijão cremoso UHT

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Summary

This paper evaluates the physical-chemical changes in UHT-processed *Requeijão cremoso* (RC_{UHT}) during 180 days storage at 5 and 25 °C. RC_{UHT} was produced from directly acidified heated skim milk with added cream, emulsifying salts and sodium chloride. The product was subsequently UHT sterilized (143 °C/3-5 s), cooled (55 °C), aseptically packaged and stored at 5 and 25 °C for 180 days. Samples were evaluated and compared for their texture profile (TPA) and instrumental colour after 1, 30, 60, 90, 120, 150 and 180 days storage (lightness, yellowness and whiteness index). No significant differences ($p > 0.05$) were found in the texture and colour parameters between the RC_{UHT} samples stored at 5 and 25 °C throughout the 180-day-storage period, with the exception of elasticity after 150 days. No significant interactions could be observed between the samples and storage time, i.e. the storage temperatures (5 and 25 °C) did not significantly affect the texture and colour parameters of RC_{UHT} ; these findings indicate that RC_{UHT} does not require refrigerated storage (5 °C) and may be kept at 25 °C without impairing the texture characteristics and/or colour (browning) of the product during 180 days. However, a detailed shelf life study of RC_{UHT} with respect to its sensory analysis is indispensable for determining the "Best before" date.

Key words: *UHT Requeijão cremoso; Texture profile; Instrumental colour; Storage.*

Resumo

Alterações físico-químicas ocorridas no requeijão cremoso (RC_{UHT}) durante o período de estocagem de 180 dias a 5 e 25 °C foram avaliadas neste trabalho. Os RC_{UHT} foram processados a partir de massa obtida por acidificação direta a quente de leite desnatado, adicionada de creme de leite, sal fundente e cloreto de sódio. Os requeijões foram esterilizados em processo UHT (143 °C/3-5 s), resfriados (55 °C), envasados assepticamente e estocados a 5 e 25 °C por 180 dias; sendo avaliados e comparados após 1, 30, 60, 90, 120, 150 e 180 dias com relação ao perfil de textura (TPA) e à cor instrumental (luminosidade, cor amarela e índice de branquura). Não houve diferença significativa ($p > 0,05$) nos parâmetros de textura e cor entre os RC_{UHT} estocados a 5 e 25 °C durante o período de estocagem de 180 dias, exceto na elasticidade em 150 dias, não houve interação significativa entre as amostras e o tempo de estocagem, ou seja, as temperaturas de estocagem do RC_{UHT} (5 e 25 °C) não afetaram significativamente os parâmetros de textura e cor, durante o período de estocagem. De acordo com os resultados obtidos em relação aos parâmetros de textura e cor do RC_{UHT} , o mesmo não necessitaria ser estocado sob refrigeração (5 °C), podendo ser acondicionado ou mantido a 25 °C, sem prejudicar suas características de textura ou causar problemas na cor do produto (escurecimento) durante o período de 180 dias. Porém, é imprescindível o estudo da vida de prateleira do RC_{UHT} por meio de análise sensorial para determinar o período de validade aconselhável nestas temperaturas (5 e 25 °C), de forma a garantir a qualidade e a segurança do produto, necessárias para o seu consumo.

Palavras-chave: *Requeijão cremoso UHT; Perfil de textura; Cor instrumental; Estocagem.*

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1 Introduction

Requeijão cremoso is a typical Brazilian type of processed cheese obtained by melting a blend of fresh cheese curd, dairy fat, water and emulsifying salts. The total production of this dairy product increased by 363.64% between 1991 and 2005, clearly illustrating its great commercial value and potential (ABIQ, 2005).

Traditional *requeijão cremoso* is generally made using blending and homogenizing equipment provided with direct and indirect vapour injection systems, such as the Stephan/Geiger Universal machine. A viable technological alternative for the manufacture of *requeijão cremoso* on completion of the melting process, is to heat the product in a heat exchanger to sterilizing temperatures and subsequently fill into aseptic containers.

In processed cheese spreads such as *requeijão cremoso*, the texture is one of the most important determinants of final product quality (RAPACCI *et al.*, 1998). Instrumental texture analysis (TPA-Texture Profile Analysis) is quick and easy to perform, and can be used to evaluate overall quality and monitor the manufacturing processes of processed cheeses. In addition, this technique can also be used to evaluate new manufacturing processes and/or procedures, the introduction of new ingredients into formulas, changes in the chemical composition and the impact of different storage conditions and new package types.

Colour is another key factor in food quality assessment and may be evaluated subjectively (visually) or objectively by instrumental measuring methods, using colour scales to determine the colour and colour differences (MABON, 1993). Objective colour measurements provide objective parameters that can be used, amongst other applications, as quality indices for raw or processed foods, for the determination of a series of quality aspects and/or quality specifications of a food product, or to evaluate quality changes that result from processing, storage or other factors (GIESE, 2000).

Current legislation allows the addition of colours to processed cheese. However, independent of the use of colouring agents, several factors related to the raw materials and their processing may alter the colours of processed cheeses, which typically vary from creamy white to white. Cheese colour defects, such as the development of a pale brownish yellow colour may be caused by the Maillard reaction, in which amino groups of proteins react slowly with reducing sugars to form brown pigments and aromatic compounds (MEYER, 1973). According to Meyer (1973) and Furtado and Lourenço Neto (1994), browning caused by Maillard reactions and caramelization are common defects that may occur when inadequate processing conditions or raw materials containing excessive levels of lactose are used. However, these defects

may also be caused by the addition of WPC (Whey Protein Concentrate), which, according to Morr and Ha (1993), may contain variable levels of compounds capable of generating off-flavours and/or colour defects that eventually intensify due to inadequate storage conditions of temperature and/or humidity, for example.

The objective of the present study was to evaluate changes in the texture parameters (firmness, adhesiveness, springiness or elasticity, cohesiveness) and colour parameters (lightness, yellow colour, whiteness index) in UHT *requeijão cremoso* during 180 days of storage.

2 Material and methods

Three identical batches of *requeijão cremoso* were processed by the Van Dender *et al.* (2002) method, i.e. melting of fresh cheese curds obtained by direct-heat acidification of skim milk, with the simultaneous addition of cream, emulsifying salts (2.5% JOHA S9), sodium chloride (1.5%) and water, in order to obtain a product containing approximately 37% total dry matter and 60% fat on a dry basis. Long-life/UHT *requeijão cremoso* (RC_{UHT}) was then produced by sterilizing the melted cheese mass (143 °C/3-5 s) followed by cooling (55 °C) and aseptic filling into 125 mL square Tetra Brik packages (Figure 1). The *requeijão* samples were stored at 5 and 25 °C and analyzed for their texture profiles (TPA) and instrumental colour 1, 30, 60, 90, 120, 150 and 180 days after manufacture.

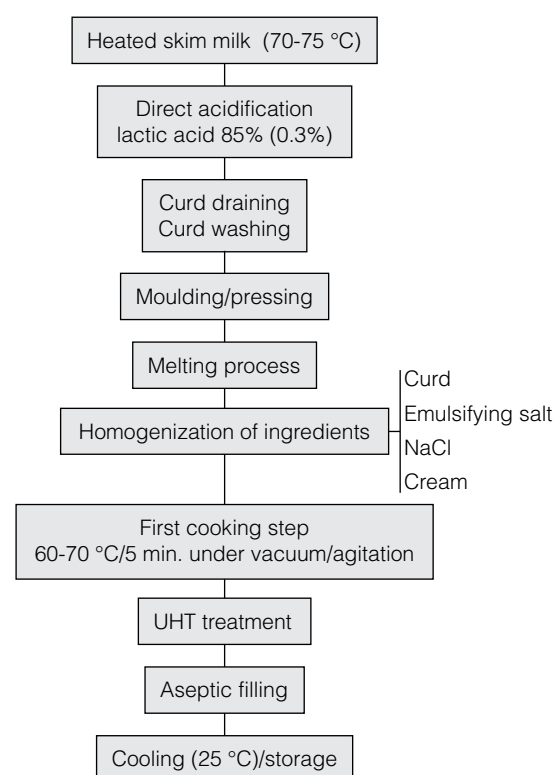


Figure 1. Manufacturing process of RC_{UHT}.

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The physical-chemical composition of the RC_{UHT} was determined one day after manufacture in terms of:

- pH (pH meter Micronal B-375);
- titratable acidity (INSTITUTO ADOLFO LUTZ, 1985);
- fat, Gerber-van Gulik method (INSTITUTO ADOLFO LUTZ, 1985);
- TDM: total dry matter (INTERNATIONAL DAIRY FEDERATION, 1982);
- FDB: fat on a dry basis was calculated (FDB = [% Fat/ %TDM] x 100);
- total nitrogen content: Nt (INTERNATIONAL DAIRY FEDERATION, 1964);
- nitrogen soluble at pH 4.6: NS pH 4.6 (VAKALERIS and PRICE, 1959);
- nitrogen soluble in 12% TCA: NNP (ASCHAFFENBURG and DREWRY, 1959);
- Pt: total protein was calculated (Nt x 6.38);
- ash (HORWITZ, 2000);
- salt: NaCl (SERRES *et al.*, 1973);
- lactose (ACTON, 1977);
- minerals content: (P, Ca, Na, Mg) (HORWITZ, 2005); and
- total caloric value (kcal.100 g⁻¹ of product) (KALIL, 1975; PASSMORE *et al.*, 1975; UNITED STATES DEPARTMENT OF AGRICULTURE, 1963).

The texture profile analysis was performed according to the method described by Rapacci (1997). *Requeijão* samples (50 g ± 2) contained in aluminium capsules (5.0 cm internal diameter and 2.6 cm height) at 10 °C were analyzed using a computerized texture measuring device (Texture Profile Analyser Model TA-XT2 – Stable Micro Systems).

Instrumental colour was evaluated using a Macbeth Colour Eye 2020 colorimeter and the COMCOR 1500 Plus computer program. Samples of approximately 25 mL *requeijão cremoso* were enclosed in glass capsules and submitted to analysis. The L* (lightness) and +b* (yellow colour) values were expressed according to the CIELab system, while the whiteness index was expressed according to the Hunter Lab system, both determinations being performed using D65 as the reference illuminant and the 10° standard observer angle. The whiteness index is a numeric value that indicates the degree of similarity between the light reflected by the sample and the light reflected by a selected white standard. The instrument was calibrated and configured to read in the reflectance-

specular excluded mode, using a white ceramic testing tile - a calibration standard (Macbeth Ref. STD) supplied by the manufacturer of the instrument.

The *requeijão cremoso* experiments were conducted in triplicate and in a randomized order. The results were statistically analyzed by ANOVA and then submitted to the Tukey test to determine any significant differences between the means.

3 Results and discussion

The physical-chemical composition of the RC_{UHT} is shown in Table 1.

Since the total dry matter content (TDM) of the RC_{UHT} was somewhat lower than desirable (35-37%), the moisture content (66%) of the product slightly exceeded the upper limit set by the legislation of 65 g.100 g⁻¹. This was due to the need to add a larger amount of water during the manufacture of the UHT *requeijão cremoso* to improve the flow of the product and facilitate sterilization by preventing clogging of the product passages inside the heat exchanger. The fat content, determined on a dry weight basis (FDB) (59%), was greater than the minimum limit established by the legislation. *i.e.* 55 g.100 g⁻¹ (BRASIL, 1997). The pH values of the *requeijão* samples manufactured for the purpose of this study were within the limits (5.4-6.2) quoted in the literature (FERNANDES *et al.*, 1985; RAPACCI and VAN DENDER, 1998). The fat and fat in the dry matter contents were close to those found by Silva (2003) – around 20.93 and 58-59%, respectively – and close to the values reported by Rapacci (1997) for *requeijão cremoso samples* produced by the direct-heat acidification process. The protein contents were greater

Table 1. Mean values for the results of the physical-chemical analyses of the three batches of RC_{UHT}.

Analysis	RC _{UHT}
pH	6.08 ± 0.08
Titratable acidity (g.100 g ⁻¹)	0.61 ± 0.06
Fat (g.100 g ⁻¹)	19.91 ± 1.52
TDM (g.100 g ⁻¹)	33.78 ± 1.78
FDB (g.100 g ⁻¹ TDM)	58.88 ± 1.84
Nt (g.100 g ⁻¹)	1.73 ± 0.13
NS pH 4.6 (g.100 g ⁻¹)	0.09 ± 0.04
NNP (g.100 g ⁻¹)	0.04 ± 0.02
Pt (g.100 g ⁻¹)	11.11 ± 0.93
Ash (g.100 g ⁻¹)	1.78 ± 0.03
NaCl (g.100 g ⁻¹)	0.54 ± 0.03
Lactose (g.100 g ⁻¹)	0.63 ± 0.15
Ca (mg.100 g ⁻¹)	191.94 ± 17.64
P (mg.100 g ⁻¹)	373.12 ± 22.94
Na (mg.100 g ⁻¹)	463.46 ± 38.55
Mg (mg.100 g ⁻¹)	8.12 ± 1.18
Caloric value (kcal.100 g ⁻¹)	226.16 ± 16.61

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than the values obtained by Silva (2003) and Rapacci (1997), and the NS pH 4.6 values were similar. The ash, salt, lactose and mineral contents were lower than the values reported by Silva (2003) for traditional *requeijão*. The caloric value of the RC_{UHT} (226 kcal.100 g⁻¹) was close to the values found by Silva (2003) for experimentally produced *requeijão cremoso* processed in Tecnotat (210 kcal.100 g⁻¹) and also similar to the caloric value of commercial *requeijão cremoso* types (234 kcal.100 g⁻¹).

The results obtained for the texture parameters of the RC_{UHT} samples stored at 5 and 25 °C throughout the storage period (1, 30, 60, 90, 120, 150 and 180 days) (n = 2) are shown in Table 2.

No significant difference (p > 0.05) was observed between the texture parameters of the RC_{UHT} samples stored at 5 and 25 °C during the 180 day-storage period with the exception of springiness (i.e. elasticity) after 150 days, where a reduction in springiness and a concomitant increase in cohesiveness of the RC_{UHT} samples stored at 5 °C was observed. According to Verma; Gupta (1981), characteristics such as springiness and cohesiveness depend on the structure and rearrangement of the protein molecules, which may have undergone changes during the course of storage that only became more perceptible after 150 days.

The results of the colour analyses (L*, b*, IB) carried out throughout storage (1, 30, 60, 90, 120, 150 and 180 days) (n = 3) for the RC_{UHT} samples stored at 5 and 25 °C, are presented in Table 3.

The colour parameter values show there was a tendency for an increase in yellowness (b) and concomitant reduction in the whiteness index values (IB) with time. Furthermore, the results suggest that the storage temperatures studied did not affect (p > 0.05) the colour characteristics of the samples during the storage period investigated, a finding in line with results reported by Kristensen et al. (2001), who evaluated the colour parameters (L*, a* e b*) of processed cheese stored (a) exposed to light and (b) in the absence of light for 1 year at 5, 20 and 37 °C. The authors observed that the numerical L* value of processed cheese decreased with time at all storage temperatures and to a more significant extent at 37 °C, and that at the same time the b* value of the samples stored at 37 °C significantly increased, whereas practically no increase was observed in any of the processed cheese samples stored at 5 or 20 °C.

Finally, no influence of the storage time on the RC_{UHT} samples stored at 5 and 25 °C was shown in this study, and the temperatures did not influence the texture and colour parameters during the storage period investigated (180 days).

Table 2. Textural properties of RC_{UHT} (5 and 25 °C).

Texture parameters		Days						
		1	30	60	90	120	150	180
Firmness (g)	RC _{UHT} 5 °C	22.0 ± 2.0 ^a	22.7 ± 5.7 ^a	21.3 ± 3.6 ^a	24.1 ± 7.0 ^a	23.0 ± 7.9 ^a	19.5 ± 3.2 ^a	21.8 ± 5.6 ^a
	RC _{UHT} 25 °C	22.0 ± 2.0 ^a	20.2 ± 3.1 ^a	20.1 ± 2.2 ^a	22.4 ± 3.5 ^a	22.1 ± 1.4 ^a	21.6 ± 1.9 ^a	21.7 ± 2.9 ^a
	LSD (5%)	2.6	5.9	3.8	7.1	7.3	3.4	5.7
Interaction A*t	n.s.	p = 0.88						
Adhesiveness ² (g.s)	RC _{UHT} 5 °C	-62.7 ± 20.4 ^a	-69.9 ± 41.4 ^a	-61.5 ± 28.1 ^a	-80.6 ± 48.5 ^a	-77.3 ± 54.5 ^a	-68.8 ± 40.7 ^a	-64.7 ± 37.5 ^a
	RC _{UHT} 25 °C	-62.7 ± 20.4 ^a	-55.0 ± 25.1 ^a	-55.2 ± 18.6 ^a	-67.9 ± 26.1 ^a	-63.2 ± 13.9 ^a	-62.4 ± 13.6 ^a	-64.3 ± 20.2 ^a
	LSD (5%)	26.2	44.0	30.7	50.1	51.1	39.0	38.8
Interaction A*t	n.s.	p = 0.99						
Springiness ¹	RC _{UHT} 5 °C	0.97 ± 0.02 ^a	0.95 ± 0.05 ^a	0.97 ± 0.02 ^a	0.97 ± 0.03 ^a	0.96 ± 0.04 ^a	0.93 ± 0.03 ^b	0.96 ± 0.05 ^a
	RC _{UHT} 25 °C	0.97 ± 0.02 ^a	0.94 ± 0.05 ^a	0.96 ± 0.03 ^a	0.97 ± 0.02 ^a	0.98 ± 0.01 ^a	0.97 ± 0.02 ^a	0.96 ± 0.02 ^a
	LSD (5%)	0.03	0.06	0.04	0.04	0.04	0.03	0.05
Interaction A*t	n.s.	p = 0.34						
Cohesiveness ¹	RC _{UHT} 5 °C	0.81 ± 0.05 ^a	0.82 ± 0.05 ^a	0.82 ± 0.04 ^a	0.84 ± 0.07 ^a	0.84 ± 0.07 ^a	0.91 ± 0.15 ^a	0.83 ± 0.07 ^a
	RC _{UHT} 25 °C	0.81 ± 0.05 ^a	0.82 ± 0.05 ^a	0.82 ± 0.03 ^a	0.83 ± 0.04 ^a	0.83 ± 0.03 ^a	0.83 ± 0.03 ^a	0.83 ± 0.05 ^a
	LSD (5%)	0.07	0.06	0.04	0.07	0.07	0.14	0.08
Interaction A*t	n.s.	p = 0.79						

¹Non-dimensional values; ²Negative values; LSD = least significant difference; ²Means followed by the same letter are not statistically different at the 5% significance level; and n.s. = not significant (p > 0.05).

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Table 3. Colour parameters of RC_{UHT} (5 and 25 °C).

Days	Variable	RC _{UHT} 5 °C	RC _{UHT} 25 °C	LSD (5%)
1	Lightness (L*)	87.1 ± 1.0 ^a	87.1 ± 1.0 ^a	2.60
1	Yellow (b*)	12.0 ± 2.7 ^a	12.0 ± 2.6 ^a	5.97
1	Whiteness index	52.2 ± 5.5 ^a	52.2 ± 5.5 ^a	13.70
30	Lightness (L*)	87.5 ± 0.8 ^a	87.4 ± 0.8 ^a	4.70
30	Yellow (b*)	12.7 ± 2.6 ^a	13.5 ± 2.3 ^a	5.70
30	Whiteness index	50.7 ± 5.7 ^a	48.7 ± 5.5 ^a	16.10
60	Lightness (L*)	87.1 ± 1.0 ^a	85.7 ± 1.5 ^a	2.80
60	Yellow (b*)	13.4 ± 2.3 ^a	14.4 ± 1.9 ^a	4.80
60	Whiteness index	48.5 ± 4.5 ^a	44.8 ± 3.3 ^a	10.50
90	Lightness (L*)	86.0 ± 1.0 ^a	85.8 ± 1.4 ^a	5.10
90	Yellow (b*)	13.6 ± 2.8 ^a	14.4 ± 2.3 ^a	5.90
90	Whiteness index	47.1 ± 7.5 ^a	44.9 ± 5.6 ^a	17.10
120	Lightness (L*)	85.5 ± 0.8 ^a	85.2 ± 0.4 ^a	1.50
120	Yellow (b*)	13.8 ± 2.5 ^a	14.9 ± 2.7 ^a	5.90
120	Whiteness index	46.1 ± 5.3 ^a	43.2 ± 6.1 ^a	3.90
150	Lightness (L*)	85.5 ± 1.0 ^a	84.9 ± 0.5 ^a	1.80
150	Yellow (b*)	14.1 ± 2.5 ^a	15.3 ± 2.4 ^a	5.50
150	Whiteness index	45.3 ± 5.2 ^a	41.9 ± 5.6 ^a	12.20
180	Lightness (L*)	85.9 ± 0.4 ^a	84.9 ± 0.6 ^a	1.20
180	Yellow (b*)	13.9 ± 2.4 ^a	15.4 ± 2.6 ^a	5.60
180	Whiteness index	46.2 ± 5.3 ^a	41.8 ± 5.9 ^a	12.80
Interaction A*t	L* = n.s.	p = 0.85		
Interaction A*t	b* = n. s.	p = 1.00		
Interaction A*t	IB = n. s.	p = 1.00		

LSD = least significant difference; Means followed by the same letter do not statistically differ at the 5% significance level; and n.s. = not significant ($p > 0.05$).

4 Conclusions

Based on the results obtained for the texture and colour parameters throughout storage under the conditions studied, it was concluded that The RC_{UHT} did not require refrigerated storage (5 °C). The results clearly demonstrated that the product could be stored or kept at 25 °C with no detrimental effect on its textural characteristics and/or colour attributes (browning) during 180 days storage. Nonetheless, it is indispensable that a shelf-life study be conducted to determine, by means of sensory analyses, the recommended "Best before" date for RC_{UHT} stored at these temperatures (5 and 25 °C) so as to assure product quality.

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