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Comparison of sensory shelf-life estimation of a beverage assessed in two locations

Comparación de la estimación de vida útil sensorial de una bebida en dos emplazamientos

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Abstract
Sensory Shelf-Life (SSL) estimation of a product consists of the sensory evaluation of a set of samples with different storage times, in which the test location plays an important role. The test location not only defines how the product is sampled and perceived, but it can also lead to different results with a given set of samples and consumers. This study compared the SSL estimation affected by two test locations: Central Location Test (CLT) and Home Use Test (HUT). Lemon-flavoured juice was used as a case study.
In the CLT, 112 consumers tested 50 ml of the sample (a small serving), whereas in the HUT, 300 consumers received a whole sealed bottle and tasted their regular consumption serving. In both cases, consumers were asked to express a decision of acceptance or rejection ("Would you normally consume this product? Yes or No"). Data was analysed using survival analysis statistics. No significant differences were found when estimating SSL in HUT and CLT.
This may be considered as the starting point for future investigations that can certainly confirm that the estimation of the SSL can be carried out by means of a conventional test, in CLT, considering its advantages in terms of cost and time invested.

Keywords: sensory shelf-life, Central Location Test, Home Use Test, survival analysis, censored data.

Resumen
La estimación de la Vida Útil Sensorial (VUS) de un producto consiste en la evaluación de un conjunto de muestras con diferentes tiempos de almacenamiento en la que el emplazamiento cumple un papel importante. Se pueden obtener diferentes resultados en diferentes emplazamientos con un conjunto de muestras y consumidores determinados. En este estudio se comparó la VUS evaluada en dos emplazamientos: Prueba de Ubicación Central (CLT) y Prueba de Uso Doméstico (HUT). Se utilizó agua saborizada como caso de estudio.
En la CLT, 112 consumidores probaron 50 ml de muestra (una porción) y, en la HUT, 300 consumidores recibieron una botella cerrada y degustaron su porción habitual de consumo. En ambos casos, se pidió a los consumidores que expresaran una decisión de aceptación o rechazo. Los datos se analizaron mediante estadísticas de supervivencia. No se encontraron diferencias significativas al estimar la VUS en la HUT y la CLT.
Esto puede considerarse el inicio de futuras investigaciones que permitan establecer con certeza que la estimación de la VUS puede realizarse mediante el empleo del test convencional, en la CLT, con la ventaja que ello conlleva en cuanto a coste y tiempo invertido.

Palabras clave: vida útil sensorial, Prueba de Ubicación Central, Prueba de Uso Doméstico, análisis de supervivencia, datos censurados.

1. Introduction

Sensory Shelf-Life (SSL) estimation of a food product consists of evaluating the sensory characteristics of a set of samples with different storage times [1]. Survival analysis has become one of the most popular methodologies for SSL estimation, focusing on the risk of consumer rejection rather than on product deterioration [2;3;4]. Experimental work is relatively simple: a group of consumers tasted samples with different storage times or levels of sensory defect and answered whether they accepted or rejected them. This decision was in line with typical consumer behaviour when dealing with a food product nearing the end of its SSL or approaching intolerable sensory limits [5].

Sensory studies with consumers can be carried out in different locations and, according to that, environmental conditions are different as well as the way in which tested samples are presented to consumers [6].

In standardised situation tests, such as Central Location Tests (CLTs) and laboratory studies, a consumer tastes a small serving of a product, for example, a quarter of an *alfajor* [7], 50 g of yoghurt [8;4] or a slice of tomato [9]. In a SSL study, consumers have to taste six or seven samples with different storage times under standardised consumption conditions [10;6]; in this way, they can taste three of them, take a break and drink some water as a palate cleanser, and then proceed to taste the remaining three samples. This is one of the most popular (or common) methods. These kinds of tests are usually performed in a university classroom, a shopping centre or a sensory analysis laboratory, among other facilities. The main disadvantage is that standardised preparation procedures and product handling protocols might not necessarily mimic consumer behaviour and experience at home, i.e., they might differ from natural consumption situations [6].

In contrast, real environments (such as Home Use Tests or HUTs) constitute another possibility. In this case, consumers receive a whole sealed product, then they prepare it in their own way, choose the moment and taste a regular consumption serving. For example, a pizza [11] or a chocolate bar [12]. The product is prepared and/or consumed under natural conditions, facilitating information collection over repeated consumption of the product rather than a first impression only. The advantage is that this approach allows for gathering more information regarding the product in general [6].

It should be noted that none of the examples mentioned above, about whole sealed products evaluated in HUTs, correspond to SSL studies. Some studies on SSL have only evaluated the effect of context or environment using the evoked context methodology [13; 14]. That is, although the influence of context has been studied, consumers did not taste the whole product in a real consumption environment or in the natural way they generally would. Elizagoyen *et al*. (2017) [15] studied the behaviour of consumers considering two different occasions: purchase and home consumption. In this latter study, survival analysis statistics were applied to estimate the optimal ripening indexes of bananas based on hue-angle measurements, revealing that purchase occasions were lower than consumption occasions for home. Using a model based on survival analysis statistics, Sosa *et al*. (2008) [16] compared the optimal salt concentration in French-type bread both in HUTs and CLTs.

No studies have been conducted to determine whether differences exist in the SSL estimation when a consumer tastes a small serving of a product in a CLT versus a regular serving in a HUT. Therefore, this was the objective of the present study.

2. Materials and methods

2.1 Samples

From a batch of fresh samples kept at a cooling temperature, each of them was stored in a chamber at 24 °C and exposed to 12 hours of light a day with daylight-type fluorescent lamps to simulate bottle conditions on supermarket shelves.

Three fresh batches were used to ensure that all conditions originated from fresh samples. One batch was used at the beginning of the trial (from which times T6, T5, T4 and T3 were taken), another one in the middle of the trial (from which times T2 and T1 were taken) and a final batch which corresponded to T0 or the fresh sample.

Each time the fresh sample was replaced, a panel of trained evaluators and assessors performed a triangle test under the guidelines of ISO 4120 [17]

(Sensory analysis. Methodology. Triangle test.) for similarity tests, ensuring there were no variations in the different batches.

Storage times for both tests (small serving in a CLT and regular serving in a HUT) are presented in Table 1.

Table 1. Storage times for each sample of the corresponding lemon-flavoured juice.

Storage time (days)	Sample
0	T0
90	T1
150	T2
210	T3
240	T4
270	T5
300	T6

2.2 Methodology

Following the guidelines proposed by Hough (2010) [6] for SSL estimation, the employed methodologies were different for a small serving evaluated in a CLT in comparison with a regular serving evaluated in a HUT, as described below:

a) To evaluate a small serving in a CLT: this test was conducted in the Instituto Superior Experimental de Tecnología Alimentaria (from Spanish, Higher Experimental Institute of Food Technology or ISETA), equipped with individual booths, daylight type fluorescent lamps, air extractors, and controlled temperature. 112 frequent consumers of lemon-flavoured drinks were recruited [18], whose average age was between 18 and 60 years old and who were from Nueve de Julio city.

Consumers evaluated 7 samples corresponding to 7 storage times (Table 1). 50 ml of each sample was served at 12 ± 2 °C in plastic cups with a maximum capacity of 70 ml and coded with a three-digit number. For each sample, consumers were asked to express a decision of acceptance or rejection (“Would you normally consume this product? Yes or No”).

The presentation order of the samples was balanced over consumers.

b) To evaluate a regular serving in a HUT: this test was conducted at the home in a real consumption environment. We used the methodology developed by Araneda *et al*. (2008) [19]. Following the guidelines of Libertino *et al*. (2011) [20], 300 consumers with the same consumption and sociodemographic characteristics as in the CLT participated in the test, and they also had to answer (“Would you normally consume this product? Yes or No”). For each sample or experimental unit, they were divided into 6 groups of 50 consumers (from T1 to T6 in Table 1). Each group was composed of different individuals, and participants in the HUT did not participate in the CLT. This type of data is known as Current-Status Data (CSD) in survival analysis statistics [21]. In contrast to conventional designs, where consumers evaluate the fresh sample and, if they accept it, proceed to further evaluations; CSD designs do not require consumers to evaluate the fresh sample, because no further evaluation of the samples will occur. The premise of the design is that each consumer evaluates a single sample. Thus, if they reject the sample, we already know they are not eligible for a task that will not be required of them [20].

Each consumer received a sealed 500 ml bottle of lemon-flavoured juice, without a commercial label and coded with a three-digit number. They were instructed to consume as much as they normally would, at the temperature they normally prefer, at the time they want and accompanied by the food of their choice.

Ethics statement: this study was approved by the Ethics Committee of the Higher Experimental Institute of Food Technology (ISETA), and informed consent was obtained from each subject prior to their participation.

2.3 Statistical analysis

To estimate the SSL of a product, the first step is to obtain censored data based on participants’ acceptance or rejection of the question: “Would you normally consume this product? Yes, or No?” [6].

As it was explained in Section 2.2, the methodology employed for evaluations in CLTs and HUTs was different and, for this reason, data treatment to collect censored data is also different. The procedure used in each case is described below. In a CLT, the conventional methodology was applied, following the same model as the one developed by Hough (2010) [6]. It is then assumed that a random variable T represents the storage time at which the consumer rejects the sample. Thus, the rejection function can be defined as the probability of a consumer to reject a product before time *t*, to be precise, F(t)= P (T ≤ t).

The moment at which the consumer rejects a sample depends on the product storage time. However, since the exact time of rejection is not directly observed, the results are considered as censored times [22]. For instance, data from 3 consumers are presented in Table 2 to illustrate the different types of censoring.

Table 2. Examples of censored data obtained using the conventional methodology (small serving in the CLT).

Consumer	Storage time (days)							Censoring
	0	90	150	210	240	270	300	
1	Yes	Yes	Yes	Yes	No	No	No	interval: 210 – 240
2	Yes	Yes	Yes	Yes	Yes	Yes	Yes	right: > 300
3	Yes	No	Yes	Yes	No	No	No	left: ≤240

Yes/No: answer to the question "Would you normally consume this product? Yes or No"

In the case of *Consumer 1,* the data are interval-censored because the precise storage time (between 210 days and 240 days) at which the consumer would begin to reject the product is not known. For *Consumer 2,* rejection is assumed to occur in a storage time after than 300 days, resulting in right-censored data. In the matter of *Consumer 3,* their data was considered left-censored. This constitutes a special case of interval-censoring with the lower bound being equal to Time=0. On this occasion, it could be interpreted as T≤ 90 days or T ≤ 240 days, and we have considered the latter option.

The likelihood function (Equation 1), used to estimate the rejection function [24], is a mathematical expression that represents the joint probability of obtaining the observed data from the consumers in the study, expressed as a function of the unknown parameters of the model being considered.

$$\boldsymbol{L} = \coprod_{i\varepsilon R}(\mathbf{1}-\boldsymbol{F}(\boldsymbol{r_i}))\prod_{i\varepsilon L}\boldsymbol{F}(\boldsymbol{l})\prod_{i\varepsilon I}(\boldsymbol{F}(\boldsymbol{r_i})-\boldsymbol{F}(\boldsymbol{l_i}))$$ **(Equation 1)**

R represents the set of right-censored observations ($\boldsymbol{r_i}$ corresponds to each right-censored observation), while ***L*** is the set of left-censored observations ($\boldsymbol{l_i}$ corresponds to each left-censored observation), and ***I*** represents the set of interval-censored observations. This equation illustrates how each type of censored data contributes differently to the likelihood functions.

As for the HUT, each consumer tasted a single sample corresponding to a single storage time (CSD). As an example, Table 3 illustrates the different types of censored data.

Table 3. Censored data obtained from the CSD methodology (regular serving in the HUT).

Consumer	Storage time (days)	Answer	Censoring
1	90	Yes	**right**
2	90	Yes	**right**
3	90	Yes	**right**
…	…	…	**…**
151	240	No	**left**
152	240	Yes	**right**
153	240	No	**left**
…	…	…	**…**
348	300	No	**left**
349	300	No	**left**
350	300	No	**left**

Yes/No: answer to the question "Would you normally consume this product? Yes or No"

When consumers taste a sample, there are two alternatives: 1) They accept it, which means their data is right-censored. In other words, consumers´ rejection time exceeds the duration or intensity of the tasted sample. 2) They reject it, which means their data is left-censored. Specifically, consumers´ rejection time is lower than the duration or intensity of the tasted sample.

As was previously explained, in HUTs, there is no interval censoring and, therefore, the likelihood function is:

$$\boldsymbol{L} = \prod_{i\varepsilon R}(\mathbf{1}-\boldsymbol{F}(\boldsymbol{r_i})\ \prod_{i\varepsilon L}(\boldsymbol{F}(\boldsymbol{l_i}))$$ **(Equation 2)**

R represents the set of right-censored observations ($\boldsymbol{r_i}$ corresponds to each right-censored observation) while ***L*** represents the set of left-censored observations ($\boldsymbol{l_i}$ correspond to each left-censored observation).

Once censored data for both locations were obtained, they were grouped or stacked to continue with the survival analysis. An example of the censored data from both methodologies is presented schematically in Table 4.

Table 4. Censored data from both locations (CLT and HUT).

Consumer	Tlow	Thigh	Cens	Location
1	210	240	interval	CLT
2	300	300	right	CLT
3	240	240	left	CLT
…	…	…	…	…
1	240	240	left	HUT
2	240	240	right	HUT
3	240	240	left	HUT

Column headings: consumer: identification of consumer within each group; tlow: low time interval (days); thigh: high time interval (days); cens: type de censoring; location: CLT or HUT

Survival times are typically not normally distributed; instead, their distribution is often right-skewed. In such cases, a log-linear model is employed:

$$\boldsymbol{ln(t) = \mu + \sigma W} \qquad \textbf{(Equation 3)}$$

Where ***W*** is the error distribution.

If the Weibull distribution is chosen for ***t***, the rejection function is defined as:

$$\boldsymbol{F(t) = exp\left[-exp\left(\frac{\ln(t)-\mu}{\sigma}\right)\right]} \qquad \textbf{(Equation 4)}$$

where, $\boldsymbol{exp}[-\boldsymbol{exp}]$ represents the rejection of the extreme value distribution, and $\boldsymbol{\mu}$ and $\boldsymbol{\sigma}$ represent the model parameters.

To determine whether the employed testing location (CLT or HUT) influenced the SSL estimation, the following log-linear regression model with covariates was applied [25]:

$$\boldsymbol{ln(t) = \mu + \sigma W = \beta_0 + \beta_1 Z + \sigma W} \qquad \textbf{(Equation 5)}$$

Where ***t*** represents the storage time at which a consumer rejects a sample; $\boldsymbol{\beta_0}$ and $\boldsymbol{\beta_1}$ correspond to the regression coefficients; ***Z*** represents the covariate indicating the location: 1 HUT and 0 CLT; $\boldsymbol{\sigma}$ correspond to the shape parameter, which does not depend on the covariates; and ***W*** represents the error distribution.

If the Weibull distribution is chosen for ***t***, the rejection function is defined as:

$$\boldsymbol{F(t) = exp\left[-exp\left(\frac{\ln(t)-\beta_0+\beta_1 Z}{\sigma}\right)\right]} \qquad \textbf{(Equation 6)}$$

The parameters of the log-linear model were estimated by maximising the likelihood function. Klein and Moeschberger (1997) [22] and Lindsey (1998) [26] present a complete discussion of different distributions.

To define the model that best fits the experimental data, different distributions were considered, and the log-likelihood criterion was used [6].

Survival analysis was performed using TIBCO Spotfire® S+ software (TIBCO Inc., Seattle, WA). After statistical analysis, an SSL value must be recommended, and this implies selecting an adequate percent rejection. Some authors adopted rejection levels of 25% or 50%, depending on the product [8]. This means that if a consumer tastes a product with a storage time corresponding to a 50% rejection probability, it has a 50% likelihood of being rejected by the consumer. This is consistent with other studies and international sensory analysis standards [27;28;17], which establish criteria for determining when the proportion of the population able to detect a difference is considered significant [6]. In this study, a 50% rejection threshold was adopted for SSL estimation.

3. Results and discussion

Data was best adjusted by the Weibull distribution. The location covariate was not significant, resulting in a value of p = 77%. Thus, the model without the covariate was adopted (Equation 4), whose parameters were: $\mu = 6.02$ and $\sigma = 0.63$. These parameters were used to graph the percentage of rejection versus storage time, shown in Figure 1.

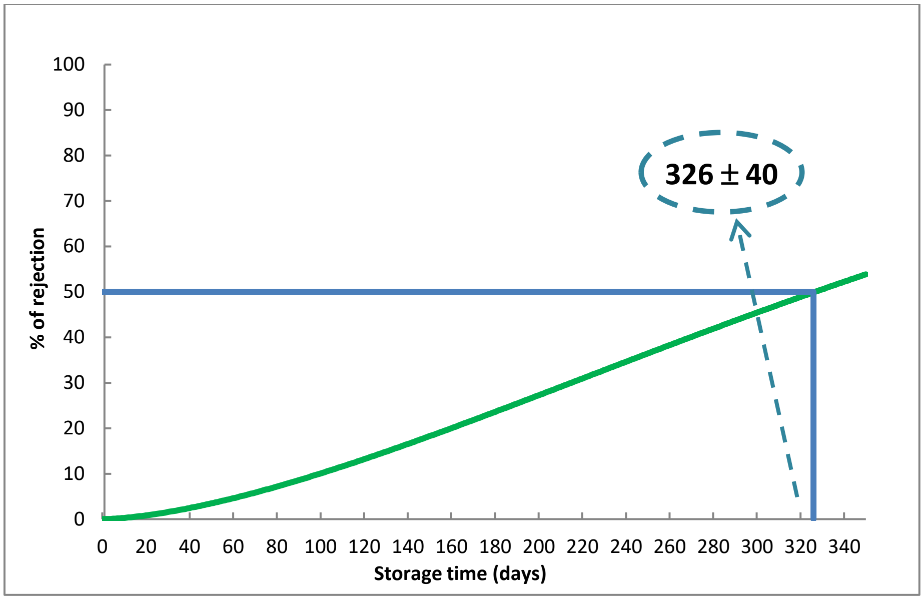

Figure 1. Percentage of rejection versus storage time.

The estimated SSL value corresponding to 50% consumers' rejection, with their 95% confidence interval, was equal to 326 ± 40 days.

This is particularly relevant, as it provides the certainty that for this type of product, self-life can be estimated by performing conventional laboratory testing, offering advantages in terms of cost and time efficiency. However, it should be noted that standardised preparation procedures and product handling protocols in the laboratory differ from those in a natural consumption situation [6].

The SSL estimation results obtained in this study have exhibited a different behaviour from those reported in previous studies. For example, Ares *et al*. (2008) [13] used survival analysis statistics to study the influence of evoked context on the SSL of minimally processed lettuce. They found that the SSL associated with the purchase occasion was lower than that for the in-home consumption occasion. Giménez *et al*. (2015) [14] also employed survival analysis to study the effect of evoked context (consumption at home and purchase at supermarkets). The shelf-lives estimated on consumers' rejection when purchasing were shorter than those estimated based on rejection to consume. This rejection of products with different storage times or a sensory defect intensity is noteworthy and should be considered in future SSL studies. It is important to note that the referenced studies employed an evoked context methodology for evaluation, instead of the real consumption situation that was used in this study. Having said this, it would be valuable to repeat these methodologies with both similar and non-similar products as a way of validating this research.

4. Conclusion

In this study, no significant differences were found at evaluating a small serving of lemon-flavoured juice in a CLT versus a HUT. Therefore, SSL studies applying survival analysis could be carried out using either of the two methodologies. However, employing the conventional test, in CLT (which offers advantages in terms of cost and time efficiency), appears to be the recommended approach for determining SSL in consumers.

Further research should be carried out to confirm the findings of the present study with other products, while considering other factors for future studies, such as consumer age, different expiration dates, and differences between packaged and unpackaged products. It may also be of interest to replicate this study using a single environment (laboratory) to investigate the effect of the sample serving on SSL estimation under controlled conditions.

Nomenclature

SSL: Sensory Shelf-Life

CLT: Central Location Test

HUT: Home Use Test
CSD: Current-Status Data

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References

[1] Bishop, J.R. & White. C.H. (1986). Assessment of dairy product quality and potential shelf-life – A review. Journal of Protection, 49, 739-753. DOI: https://doi.org/10.4315/0362-028X-49.9.739.

[2] Giménez, A., Ares, F., & Ares, G. (2012). Sensory shelf-life estimation: A review of current methodological approaches. Food Research International, 49, 311-325. DOI: https://doi.org/10.1016/j.foodres.2012.07.008.

[3] Hough, G., Garitta, L. & Sanchez, R. (2004). Determination of consumer acceptance limits to sensory defects using survival analysis. Food Quality and Preference, 15, 729-734. DOI: 10.1016/j.foodqual.2004.02.006.

[4] Hough, G., Langohr, K., Gómez, G., & Curia, A. (2003). Survival analysis applied to sensory shelf-life of foods. Journal of Food Science, 68 (1), 359-362. DOI: https://doi.org/10.1111/j.1365-2621.2003.tb14165.x.

[5] Garitta, L., Langohr, K., Gómez, G., Hough, G. & Beeren, C. (2015). Sensory cut-off point obtained from survival analysis statistics. Food Quality and Preference, 43, 135-140. DOI: https://doi.org/10.1016/j.foodqual.2015.02.012.

[6] Hough, G. (2010). Sensory Shelf-Life Estimation of Food Products (1st ed.). CRC Press. DOI: https://doi.org/10.1201/9781420092943.

[7] Gámbaro, A., Giménez, A., Varela, P., Garitta, L. & Hough, G. (2004). Sensory shelf-life estimation of an Alfajor by survival analysis. Journal of Sensory Studies. 19, 500-509. DOI: http://10.1111/j.1745-459X.2004.050704.x

[8] Curia, A., Aguerrido, M., Langohr, K. & Hough, G. (2005). Survival Analysis Applied to Sensory Shelf Life of Yogurts–I: Argentine Formulations. Journal of Food Science, 70, 442-445. DOI: http://dx.doi.org/10.1111/j.1365-2621.2005.tb11489.x.

[9] Garitta, L., Hough, G. & Hulshof, E. (2008). Determining optimum ripening time of fruits applying survival analysis statistics to consumer data. Food Quality and Preference. 19, 747-752. DOI: http://10.1016/j.foodqual.2008.03.003.

[10] Boutrolle, I., Delarue, J., Arranz, D., Rogeaux, M. & Köster, E. (2007). Central location test vs. home use test: Contrasting results depending on product type. Food Quality and Preference 18, 3. DOI: http://dx.doi.org/10.1016/j.foodqual.2006.06.003.

[11] Ratanatriwong, P., Suk Yeung, M., Jusup, C. & Matrid, N. (2006). Comparison of Consumer Acceptances of Frozen Pizzas Assessed at Central Location Test (CLT) vs Home Use Test (HUT). Natural Science 40, (5): 197-202.

[12] Karin, W.; Annika, A.; Anna, S. 2015. Exploring differences between central located test and home use test in a living lab context. International Journal of Consumer Studies 39: 230-238.

[13] Ares, G., Giménez, A., & Gámbaro, A. (2008). Sensory shelf-life estimation of minimally processed lettuce considering two stages of consumers` decision-making process. ScienceDirect, 50, 529-535. DOI: https://doi.org/10.1016/j.appet.2007.11.002.

[14] Giménez, A., Gagliardi, A., & Ares, G. (2015). Influence of evoked contexts on consumers' rejection of two products: Implications for shelf-life estimation. Food Research International, 76, (3), 527-531. DOI: https://doi.org/10.1016/j.foodres.2015.06.041.

[15] Elizagoyen, E.S., Hough, G., Garitta, L. Fiszman, S. & Vasquez, J. (2017). Consumer's expectation of changes in fruit based on their sensory properties at purchase. The case of banana (Musa Cavendish) appearance evaluated on two occasions: Purchase and home consumption. Journal of sensory studies, 32, 4. DOI: https://doi.org/10.1111/joss.12278.

[16] Sosa, M., Flores, A., Hough, G., Apro, N., Ferreyra, V. & Orbea, M. M. (2008). Optimum Level of Salt in French-Type Bread. Influence of Income Status, Salt Level in Daily Bread Consumption, and Test Location. Journal of Food Science, 73 (8). S392-S397. DOI: https://doi.org/10.1111/j.1750-3841.2008.00898.x.

[17] ISO Standard 4120 (2004). Sensory analysis – Methodology – Triangle test. Geneva: International Standard Organization.

[18] Hough, G., Calle, M. L., Serrat, C., & Curia, A. (2007). Number of consumers necessary for shelf-

life estimations based on survival analysis statistics". Food Quality and Preference, 18, 771-775. DOI: https://doi.org/doi:10.1016/j.foodqual.2007.01.003.

[19] Araneda, M., Hough, G. & Wittig De Penna, E. (2008). Current-status survival analysis methodology applied to estimating sensory shelf life of ready-to-eat lettuce (Lactuca sativa). Journal of Sensory Studies: 23, 162–170. https://doi.org/10.1111/j.1745-459X.2007.00140.x

[20] Libertino, L.; López Osornio, M. & Hough, G. 2011. Number of consumers necessary for survival analysis estimations based on each consumer evaluating a single sample. DOI:10.1016/j.foodqual.2010.06.006

[21] Shiboski, C. (1998). Generalized additive models for current status data. Lifetime. Data analysis, 4: 29-50. DOI: https://doi.org/10.1023/a:1009652024999.

[22] Klein, J.P. & Moeschberger, S. (1997) Survival Analysis: Techniques for Censored and Truncated Data. Springer, Berlin. DOI: https://doi.org/10.1007/978-1-4757-2728-9.

[24] Garitta, L.; Hough, G. & Sanchez, R. 2004. Sensory shelf life of dulce de leche. Journal of Dairy Science, 87: 1601-1607. DOI: https://doi.org/10.3168/jds.S0022-0302(04)73314-7.

[25] Meeker, W.Q. & Escobar, L.A. (1998). Statical methods for reliability data. New York, USA: John Wiley y Sons.

[26] Lindsey, J.K. (1998). A study of interval censoring in parametric regression models. Lifetime Data Analysis, 4, 329-354.

[27] ATSM Standard E1432-04. 2006. Standard practice for defining and calculating in individual and group sensory threshold from forced-choice data sets of intermediate size. West Conshohocken, PA: American Society for Testing and Material.

[28] ISO Standard 13301 (2002). Sensory analysis – Methodology – General guidance for measuring odour, flavor and taste detection thresholds by a three-alternative forced-choiced (3-AFC) procedure. Geneva: International Standard Organization.