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Research Article

Conservation of Lemon Biscuit Produced in the Lower Sinú Region on the Department of Córdoba, Colombia

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Abstract: The objective of this study was to evaluate the useful life of lemon biscuit under different preservation systems. Lemon biscuit is a local food produced in the department of Córdoba, Colombia, it is very popular for its particular flavor and low cost. The samples were obtained from 3 local producers in the Lower Sinú region, to which potassium sorbate (0.1%) was added as a preservative during their processing. The samples were packed in two types of package (low density, polyethylene and polypropylene) and stored at temperatures of 28 and 32°C for 24 days, a lemon biscuit without sorbate and without any type of packaging was used as the control sample, which is the way it is locally marketed. Microbiological (aerobic mesophiles, lactic acid bacteria, molds and yeasts, total and faecal coliforms, *Bacillus cereus* and *S. aureus*), physicochemical (pH, acidity and weight loss) and sensorial parameters (color, taste, appearance and texture) were evaluated during storage at day 0, 6, 12, 18 and 24, respectively. Microbiological parameters of mesophiles, molds and yeasts presented significant differences ($p<0.05$) between treatments. Treatments have highly significant differences ($p<0.001$) regarding the attributes of color, appearance, taste and texture of the food. In conclusion, the flavor attribute was the determinant variable when estimating the durability of the analyzed product, the added with 0.1% potassium sorbate and packed in polypropylene bags reached 12 days of shelf life.

Keywords: Alteration, local food, packaging, shelf life, typical

INTRODUCTION

Traditional and local foods take their name because they are produced at a small and medium-scale with a local identity related to the geographical space (Kwon, 2015). These foods are very desirable for their taste, low cost and easy accessibility; however, their high perishability most of the time caused by the deficient hygienic practices during their elaboration and distribution, limits its commercialization and consumption at regional and national levels. In addition to this, few technological applications are found in their processing and marketing, these foods are sold without any packaging to protect them from environmental conditions, being an easy target for any physical, chemical or microbiological agent that can affect the product's quality and the consumer's health, resulting in economic losses of around 20% (Pascoe and Vivero, 2008), aggravating the income of small producers.

A critical aspect in marketing of indigenous foods is the absence or improper use of packaging. The packaging use in the food industry means safer and less vulnerable to pollution foods, which is reflected in higher profitability. For consumers, packaged foods represent better nutritional, sensory and microbiological properties on the product (Salas, 2012). Among the typical plastic materials used to pack foods there are found Low Density Polyethylene (LDPE), Polyvinyl Chloride (PVC) and Polypropylene (PP), these have good flexibility and excellent behavior as a humidity barrier (Heldman and Lund, 2007). Preservation of typical foods can also be accomplished through the use of preservatives. Potassium sorbate is a preservative that can inhibit the activity of molds, yeasts and bacteria (Pinos and Steffania, 2010).

Native foods durability can be estimated as a function of temperature with the Arrhenius procedure. Temperature is a non-compositional factor that strongly affects reaction rates. The Arrhenius ratio is that in which kA is the constant of the Arrhenius equation, AE in joules or calories per mole, is the activation energy (the excess energy barrier that attribute A has to save for the progress of the degradation products), T is the absolute temperature (K) and R is the universal gas constant (1,9872 cal/mol.K or 8.3144 J/mol.K) In practical terms, this means that if the values of k are obtained at different temperatures and Ln k is plotted against the inverse of the absolute temperature, 1/T, a

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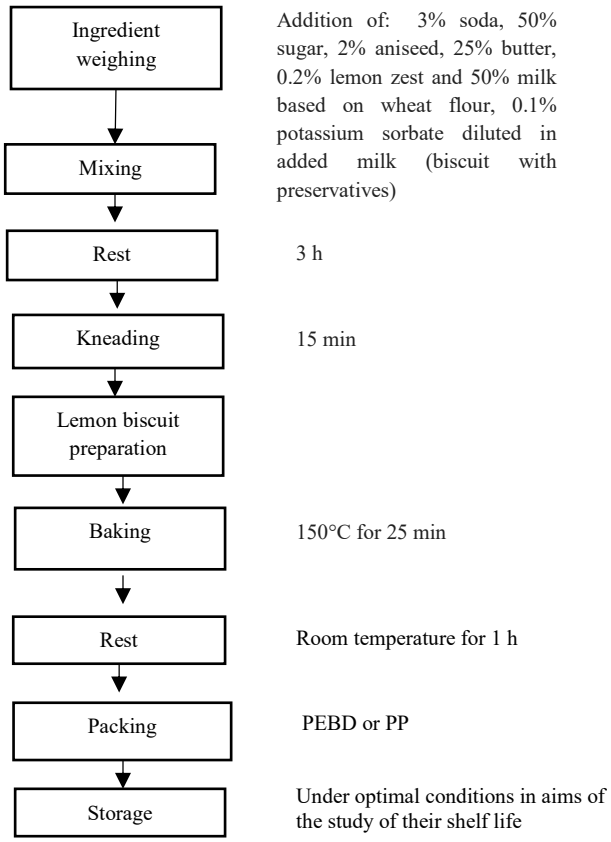

Fig. 1: Lemon biscuit preparation

straight line with a slope of -AE/R is obtained (McKellar and Xuewen, 2004) as is shown in Eq. (1):

$$K = K_A e^{\left(-\frac{A_E}{RT}\right)} \quad (1)$$

This constant serves to relate a quality attribute (*Q*) at a specific time (*t*), where initial quality (*Qo*), changes to a final quality (*Qf*) and find the useful life (*tu*) of the food as a function of said quality attribute as shown in Eq. (2):

$$tu = \frac{Ln\ Qo - LQf}{K} \quad (2)$$

It is sought that in the future, native foods take over a preponderant place in the national and international trade, many of them are the roots of a particular location and this is the reason why they can become in products with protected geographical identity. The following research aimed to propose alternative technological agro-industrial processes that extend the shelf life of lemon biscuits produced on the Department of Cordoba, in order preserve the cultural heritage and socioeconomic well-being of the inhabitants of the lower Sinú region, combining some technological processes such as temperatures use, packaging and preservatives. It is expected that the application of these processes will increase the shelf life of lemon biscuit without detriment to its nutritional and sensorial quality.

MATERIALS AND METHODS

Sampling: Samples were obtained from family companies that produce lemon biscuits in municipalities located in the area of the lower Sinú region such as (Chimá, Cotorra, Lorica, Momil and Purísima) in the department of Córdoba (Colombia). The experimental study was carried out at the University of Córdoba facilities, Berástegui headquarters, with a temperature of approximately 30°C and a relative humidity of 85%. The manufactured products under the process shown in Fig. 1 were subjected to treatments that combined the use of packaging and temperatures (Fig. 2). The samples were stored at temperatures of 28 and 32°C for 24 days.

Shelf life: Each sample was studied for its stability over time, which consisted on microbiological, physicochemical and sensory analyses. Microbiological assays comprised aerobic mesophiles, molds and yeasts, Lactic Acid Bacteria (BAL), total and faecal coliforms, *Bacillus cereus* and *S. aureus*, following the American Society of Public Health (APHA) methodology

(a) (b)

(c)

Fig. 2: Used treatments (a) Lemon biscuit with 0.1% potassium sorbate packed in low density polyethylene, (b) Lemon Biscuit with 0.1% potassium sorbate packed in polypropylene, (c) Lemon biscuit with no packaging

(Vanderzant, 1992). Physico-chemical analyses were pH acidity (AOAC, 2012) and weight loss. Sensory analyses were color, taste, appearance and texture (Instituto Adolfo Lutz, 2000). For sensory analysis, an acceptance test was conducted using a nine-point hedonic scale, a panel of 30 untrained tasters was selected. These variables were studied in the storage days: 0, 6, 12, 18 and 24, respectively. For the kinetic determination of the product's quality deterioration, the variation of each evaluated attribute in relation to time and storage temperatures was studied, for which the linear equations of order 0 and 1 that obtained a better adjustment and correlation in relation to quality behavior over time, were found. To determine the energy activation and k-value, the of the slopes of the lines obtained in each equation and the storage temperature in Kelvin degrees were used, the useful life was found with the Arrhenius equation according to each one of the studied criteria.

Experimental design: In order to evaluate the sample's characteristics over time, a completely randomized block design with a factorial arrangement of 5×3×2 was used, in divided plots, the first studied factor being storage time, the second one packing and third one the employed temperature. Analyzes were performed with 2 replicates for each treatment. A Tukey test was used to evaluate the differences between the means, with a significance level of 5%. For the analysis of the data we used the statistical package SAS version 8.1 licensed by the University of Córdoba.

RESULTS AND DISCUSSION

Microbiological characteristics: All tested samples showed absence of counts of *Staphylococcus aureus*, *Bacillus cereus*, total and faecal coliforms were within the permitted parameters (NTC 1241, 2007). By observing the deterioration of lemon biscuits over time, the alteration is mainly related to mesophilic bacteria, yeasts and molds (Table 1), consistent with the findings of Reátegui Sibina *et al*. (2001) in biscuits made with flour of five different cereals, where the microbiological analysis of biscuits in a 60 days storage showed only mesophilic and molds of a 40 cfu/g average for each microorganism. This behavior is due to the fact that molds are able to colonize substrates with lower water activity better than bacteria (Madigan *et al*., 2003), these also have been found in substrates with activity less than 0.80 water; in addition, they rapidly invade any substrate due to their dissemination efficiency and their vast enzymatic package (Bourgeois *et al*., 1995). Another bacterial inhibiting factor on biscuits is the high pH that the samples had due to the presence of sodium bicarbonate (Rodríguez, 2009) and potassium sorbate. PH values between 9.42 and 8.78 were present on the samples for day 0 and 7.93 and 7.61 for day 24; these values are within the ranges described by Maldonado and Pacheco de Delahaye (2000) in biscuits made with a mixture of wheat flour and green banana.

Table 1: Microbiological results of mesophiles, molds and yeasts on lemon biscuit (cfu/g)

Days	trat	T (°C)	Mesophiles	Molds and yeasts
0	1	28	35	<100
		32	<10	<100
	2	28	30	<100
		32	53	<100
	3	28	30	<100
		32	30	<100
6	1	28	225	<100
		32	45	<100
	2	28	35	<100
		32	90	<100
	3	28	168	<100
		32	113	<100
12	1	28	375	50
		32	83	1300
	2	28	80	<100
		32	538	<100
	3	28	672	275
		32	213	1375
18	1	28	625	125
		32	-	-
	2	28	410	50
		32	320	350
		28	1050	25
	3	32	-	-
24	1	28	805	635
	2	28	562	575
	3	28	1750	725

From day zero, a count of mesophiles was evidenced, which presented a higher growth on biscuits of treatment 3 (control) for both of the temperatures 28 and 32°C (Table 1). Fungal growth begins at day 12, appearing in the samples of treatments 1 and 3 stored at 32°C microbiological counts were above established, for this reason these treatments were removed

Table 2: Analysis of pH and acidity variance for lemon biscuit

pH		
FV	GL	CM
Model	23	0.13880**
Error	12	0.00080
Total	35	
Acidity		
FV	GL	CM
Modelo	23	0.00150**
Error	12	0.00004
Total	35	

**: Significant at 1% probability

Table 3: Average values of pH and acidity in relation to the storage time for lemon biscuits

Day	pH	Acidity
0	9.2033 a	0.1140 b
6	8.8325 b	0.1328 ab
12	8.7700 c	0.1415 a

Equal letters in the same column do not differ from each other for the Tukey test ($p<0.05$)

Table 4: Average values of pH and acidity

Temperature (°C)	pH	Acidity
28	8.9633 a	0.1283 a
32	8.9072 b	0.1306 a

Equal letters in the same column do not differ from each other for the Tukey test ($p<0.05$)

Table 5: Values of pH and acidity means in relation to the used package

Package	pH	Acidity
Potassium sorbate 0.1% in polyethylene	9.0158 b	0.1138 b
Potassium sorbate 0.1% in polypropylene	9.1358 a	0.1079 b
No packaging	8.6542 c	0.1666 a

Equal letters in the same column do not differ from each other for the Tukey test ($p<0.05$)

from the study as well as the samples of treatment 2 at 32°C on day 18. Samples stored at 28°C lasted until day 24.

Lemon biscuits packed in polyethylene and polypropylene showed lower microbiological counts than samples that were not packed (Table 1). These packages fulfill the function of good moisture barrier and decrease the rate of oxygen transfer to the food (Chica and Osorio Saldarriaga, 2003; Heldman and Lund, 2007) and the use of 0.1% potassium sorbate slows the growth of microorganisms in the product (Pinos and Steffania, 2010). When comparing the two materials used, it was found that polypropylene maintained the product in better microbiological conditions, because this material presents a greater barrier to oxygen, water vapor and CO_2 (García and Torres, 2005). The kinetics of deterioration analysis of the lemon biscuit in relation to molds, yeasts and mesophiles growth did not allow to make useful life period estimations because none of the treatments that were evaluated in this study had a logical behavior.

Physicochemical characteristics: It was evident that lemon biscuit samples had highly significant differences ($p<0.001$) in regards of pH and acidity values, that is to say, the treatments used in the study affected the physicochemical characteristics of the food (Table 2).

Table 3 shows that the highest values of pH and lower acidity were obtained on day zero because at this point the product has not yet experienced deterioration in their physicochemical properties. At 18 days of storage, samples of treatments 1 and 3 of lemon biscuits at 32°C showed microbiological counts above the recommended parameters (NTC 1241, 2007). For this reason, no further physicochemical analyzes were carried out on these samples.

In Table 4, it is observed that temperature affected biscuits' pH; the samples stored at 28°C reported the highest values. Acidity did not show a significant variation with respect to the used temperature.

The data set forth in Table 5 indicates the effect of each of the packages used on the lemon biscuit samples. It is observed that on average the polypropylene with potassium sorbate 0.1% better maintains the physicochemical characteristics of the product, although the kinetics of decay of lemon biscuit in both used packages is very similar. The ratio of pH to calculate useful life is not related because data shows an atypical behavior and it is therefore inferred that this variable should not be used to make these estimates. The acidity variable was not used to make the life time estimates because it presented a polynomial behavior.

Sensory characteristics: To determine the sensory quality of the product, color, appearance, taste and texture were evaluated, the latter being the most important characteristic in confectionery products (Hough and Witting, 2005; González, 2010). Table 6 presents the analysis of variance for the sensory characteristics of the product during its useful life. The results show that lemon biscuits had highly significant differences ($p<0.001$) with respect to color values, appearance, taste and texture of the food.

Table 6: Analysis of variance of sensory characteristics for lemon biscuits

Color		
FV	GL	CM
Model	191	2.5789**
Error	348	1.0177
Total	539	
Appearance		
FV	GL	CM
Model	191	2.4976**
Error	348	1.0432
Total	539	
Flavor		
FV	GL	CM
Model	191	5.5533**
Error	348	1.8333
Total	539	
Texture		
FV	GL	CM
Model	191	5.8187**
Error	348	1.5893
Total	539	

**: Significant at 1% probability

Table 7: Average values of sensory characteristics for lemon biscuits in relation to the day of storage

Day	Color	Appearance	Flavor	Texture
0	7.5167 a	7.4778 a	7.2889 a	7.1000 a
6	7.2778 a	7.1222 a	6.7333 b	6.5111 a
12	6.6389 b	6.6556 b	5.5500 c	5.6833 b

Equal letters in the same column do not differ from each other for the Tukey test ($p<0.05$)

Table 8: Average values of sensory characteristics in relation to storage temperature for lemon biscuits

T (°C)	Color	Appearance	flavor	Texture
28	7.1259 a	7.0889 a	6.6630 a	6.4926 a
32	7.1630 a	7.0815 a	6.3852 b	6.3704 a

Equal letters in the same column do not differ from each other for the Tukey test ($p<0.05$)

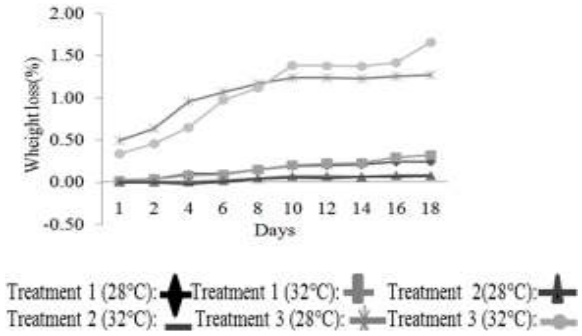

Fig. 3: Weight loss of lemon biscuit samples stored at 28 and 32°C during shelf life evaluation

Table 7 shows in the variables color, appearance and texture, on which the tasters begun to perceive statistically significant differences on day 12. On the other hand, flavor presented statistical differences for all days of storage, finding the highest scores on day zero, decreasing this score over time. At 18 days of storage, the samples from treatment 1 and 3 stored at 32°C were taken from the study; for this reason, sensory analysis of these samples was not continued and therefore a shelf life for lemon biscuits is not related.

Table 8 shows that the temperature affected the flavor of lemon biscuits, samples stored at 28°C reported the highest values. Color, appearance and texture variables did not show a significant variation with respect to the used temperature.

Figure 3 shows that the least water loss is obtained with the polypropylene packaging (treatment 2). This change has no noticeable impact on the sensory qualification of the product; tasters did not perceive significant differences in the texture of the samples stored in different packages (Table 6), because weight loss was minimal since the product is quite dry. Tasters only perceived significant differences in the product's texture as storage time passed.

CONCLUSION

The shelf life of lemon biscuits is best related to sensory variables, flavor is the attribute that better estimates the product's durability; when packed with an addition of 0.1% of potassium sorbate and in polypropylene bags, lemon biscuits reached 12 days of useful life.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interests regarding the publication of this study.

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