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Standardization of smoked and natural sausage manufacturing processes and shelf-life determination

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ABSTRACT

Objective: To determine the shelf life of sausage under the natural and smoked processes to standardize their manufacturing process, evaluate their physicochemical and microbiological quality using a mathematical model of order zero chemical kinetics.

Methodology: The sausage manufacturing process was standardized, and two cooking and preservation methods were applied: boiling and smoking in oak wood. For the shelf-life analysis, a partially staggered sampling was used. The product samples were kept refrigerated (2 to 6 °C, for 7 weeks), and physicochemical and microbiological analyses were carried out on them every week. A mathematical model based on order zero chemical kinetics was used with the obtained results to determine the shelf life of the processed products.

Results: The shelf life of sausages depends on the applied preservation process; in the case of the traditional (hot water) process, the result was 33 d, and increased to 56 d in the smoked and cooked with dry heat, due to the water content of each product, as well as the smoking antimicrobial action.

Keywords: meat products, shelf life, standardization.

INTRODUCCIÓN

Meat can form part of a balanced diet, providing beneficial and valuable nutrients for the health. Meat and meat products contain important protein levels, vitamins, minerals and micronutrients, essential for growth and development. Meat processing represents an opportunity to add value, reduce prices, promote food safety and extend shelf life. This in turn generate increased household income and improved nutrition (FAO, 2014). Meat consumption in some industrialized countries is high, in developing countries the *per capita* meat consumption of less than 10 kg, and considered insufficient and often causes undernourishment

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and malnutrition. It is been estimated that more than 2 billion people in the world suffer from essential vitamin and mineral deficiencies, particularly vitamin A, iodine, iron and zinc. Such deficiencies occur when people have limited access to micronutrient-rich foods such as meat, fish, fruits and vegetables. Most people with micronutrient deficiencies live in low-income countries and are generally deficient in more than one micronutrient. HIV/AIDS infected communities, women and children are particularly in need of highly nutritious foods such as meat. Meat processing technologies are a series of techniques and procedures used in the manufacturing of processed meat products. Meat processing makes maximum use of meat and slaughter by-products. Animal tissues, muscle meat and fat are their main ingredients. Occasionally other tissues such as viscera, skin and blood are used, which are complemented with ingredients of vegetable origin. All processed meat products on the market have been physically or chemically treated, these treatments go beyond simple cuttings of meat and its subsequent preparation as cooked meat dishes. Modern meat processing includes a series of physical and chemical treatment methods. Although only one can be used, in general, a combination of several methods is used. Modern meat product processing techniques result in safer products, which together with Good Manufacturing Practices (GMP's) generate products with a longer shelf life, which allows reducing the chemical additives used under the conditions established by the WHO and the NOM of each of the processed products. The shelf life is a study performed on each of the products to determine the time it takes for the product to reach the sanitary specifications that exceed permissible limits, which allows establishing an expiration date for each of the products. Based on the above, the shelf life of sausages was determined under natural and smoked processes, to standardize their manufacturing process, evaluate their physicochemical and microbilogical quality using a zero-order mathematical model of chemical kinetics.

MATERIALS AND METHODS

The meat products in produced a workshop and analyzed for this study were: natural and smoked sausages, vacuum-packed, from only pork leg meat, acquired from a local distributor. The sausage formulations were based on the specifications established in NMX-F-065-1985. Their evaluation period was of three months, and a partially staggered sampling was designed for shelf-life analysis by analyzing every 7 days the physicochemical characteristics of the products following the Mexican Standards (Table 1).

The microbiological evaluation of the products was carried out following the specifications in the NOM-110-SSA1-1994. Standard for the preparation and dilution of food samples for microbiological analysis and NOM-092-SSA1-1994, goods and services. standard for method for aerobic bacterial plate count. These analyses were performed every 15 d. Once the results of the physicochemical and microbiological analyses were obtained, a mathematical zero-order method of the chemical kinetics was applied to determine the days of shelf life of each of the products. This method was performed in Excel® 2018 spreadsheet, and the results were plotted in a scatter diagram and obtained by the least-squares method the linear regression obtaining the equation of the line and from this, take the values of the intercept with the x-axis, the slope of the line and the value of the correlation factor of the variables.

With these values and the maximum or minimum limit of each of the analyzed specifications, the days of shelf life of the products were calculated. The correlation factor is a determining factor to know which is the limiting variable in this study; this value should be as close to 1.0 as possible to values used for our analysis. If the correlation factor value is low, it means that the product shows stability in the assessed variable and therefore, does not represent a limiting factor that affects the shelf life of the product.

Table 1. Applied physicochemical analysis methods.

Parameters	Standard methods
pH	NMX-F-317-NORMEX-2013 Determination of pH in food and non-alcoholic beverages, potentiometric method.
Titratable acidity	NMX-F-102-NORMEX-2010 Determination of titratable acidity in foods.
Water activity a_w	NMX-F-621-NORMEX-2008 Determination of water activity in food.
% Moisture content	NMX-F-428-1982 Determination of moisture in food. Thermobalance method.

RESULTS AND DISCUSSION

Determination of natural sausage shelf life

The physicochemical analyses are shown in Table 2.

Storage days	pH	Titratable acidity [1]	Aw	Moisture content (%)
0	6.41	0.45	0.9853	65.7
7	6.44	0.55	0.9895	54.4
14	6.46	0.55	0.9886	68.5
21	6.45	0.60	0.9920	69.1
28	6.43	0.65	0.9934	46.0

Table 2. Results of physicochemical analysis of natural sausage.

The product increases its water activity due their cooking method is hot water and having a minimum number of additives, the water migrates from the product and can be observed in the product packaging. Consequently, it has more available water for microbiological decomposition, thus represent a limiting factor for the shelf life of this products.

With these results, a scatter plot was constructed for each of the variables individually, to obtain the equation of the line, and thus to determine the values of their slope, their intercept with the x-axis and the correlation factor. Figure 1 shows that the correlation factor is low, which indicates the pH stability in the product, so this is not a determining factor for the shelf life of the natural sausage.

Figure 2 shows that the acidity value increases, so it is a factor that limits the shelf life of the products.

To determine the shelf life of the natural sausages, a value of 0.70 acidity was taken as a limit, and along with the values of the intercept and the slope, the time in days was calculated.

$$t = \frac{A_e - A_o}{k}$$

$$t = \frac{0.70 - 0.47}{0.0064}$$

t=36 days of shelf life for the natural sausage. Figure 3 shows the linear regression for water activity to obtain the slope and intercept values.

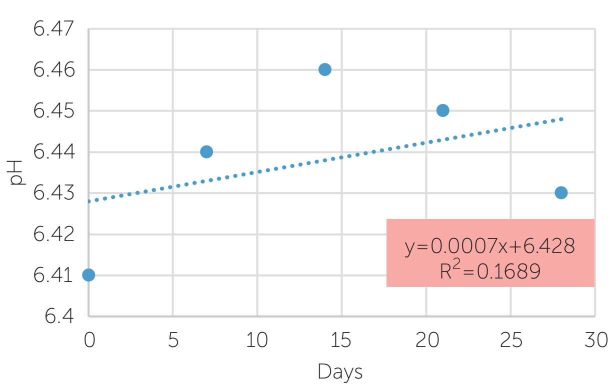

Figure 1. Linear correlation graph of the pH in the natural sausages.

Performing the operations, we obtain:

$$t = \frac{A_e - A_o}{k} \quad (4)$$

$$t = \frac{0.995 - 0.986}{0.0003}$$

t=30 days of shelf life for natural sausages.

According to the correlation factor of humidity analysis (very low value), it does not represent a limiting factor for the product's shelf life, although it does regard the a_W values, due product's humidity decreases. Regard the sanitary quality of the product, the results of microbial, analysis (mesophilic aerobic) are shown in Table 3.

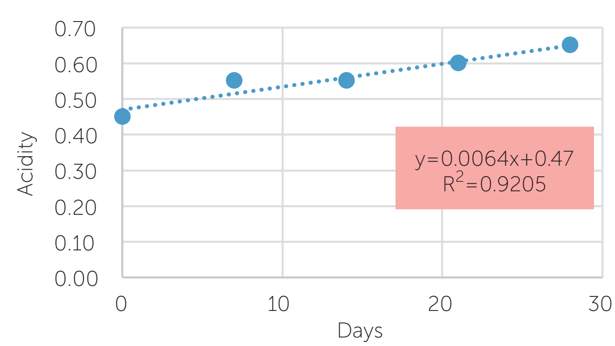

Figure 2. Linear correlation graph of the acidity of natural sausages.

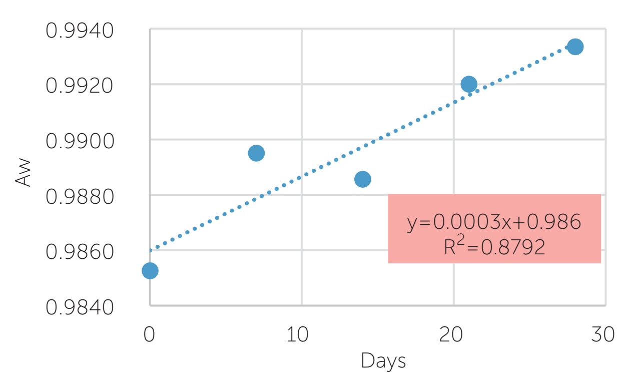

Figure 3. Linear correlation plot for the water activity in natural sausages.

With these results, the linear correlation shown in Figure 4 was performed.

Agree to Figure 5, Microbial growth increases through time, which indicates it will cause the decomposition of the product reducing shelf life. The obtained data of microbial analysis and according to the sanitary specifications of standard NMX- NMX-F-065-1985. Specifications, it was considered a maxim limit value of 200,000 CFU/g. With these values and following the shelf life formula with a order zero chemical kinetics, the shelf life of the natural sausage was obtained:

$$t = \frac{A_e - A_o}{k}$$

$$t = \frac{200,000 - 12,000}{6,314.3}$$

t=34 days of shelf life for natural sausages.

The shelf life of natural sausage it's was obtained in relation to the results of the analyses carried out on the natural sausage, an average was achieved of this research, as seen in Table 4.

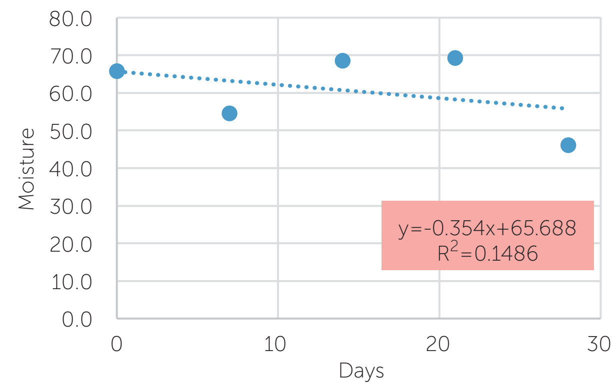

Figure 4. Linear correlation graph of the percentage moisture content in natural sausages.

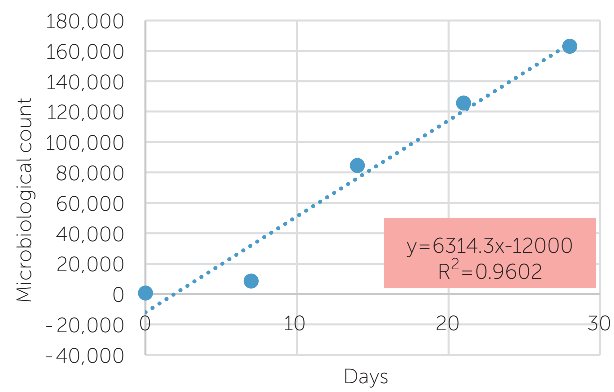

Figure 5. Linear correlation graph of microbiological analysis of natural sausages.

Table 3. Results of the microbiological analysis of sausage.

Storage days	Microbiological count (UFC*/g)
0	500
7	8,500
14	84,500
21	125,500
28	163,000

Table 4. Results of the days of shelf life of natural sausages.

Evaluated parameters	Shelf life (days)
Titratable acidity	36
Water activity	30
Microbiological count	34
Average value	33

Shelf life of smoked sausage

The results of the physicochemical analyses performed on the smoked sausage samples are shown in Table 5.

According to the results physicochemical analyses, linear relationship graphs for each of the parameters were prepared to obtain the slope data, their intercept and correlation factor to determine the days of shelf life of the smoked sausages. Figure 6 shows the correlation of the pH values in the natural sausage samples. According to the correlation factor, there is a positive relationship, so that the shelf life of the product is affected.

Table 5. Results of physicochemical analysis of smoked sausages.

Storage days	pH	Titratable acidity [1]	Aw	Moisture content (%)
0	6.09	0.6	0.9545	48.9
7	6.53	0.55	0.9769	50.9
14	6.61	0.65	0.9549	49.1
21	6.91	0.7	0.94825	51.55
28	6.67	0.65	0.9559	51.8

According to the slope values, intercept and pH limit value in the product, the days of shelf life were obtained:

$$t = \frac{A_e - A_o}{k}$$

$$t = \frac{7 - 6.254}{0.022}$$

t=34 days of shelf life for smoked sausage.

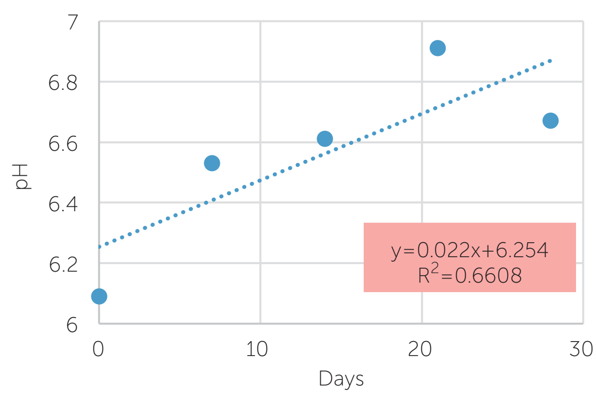

Figure 6. Linear correlation graph of the pH of smoked sausages.

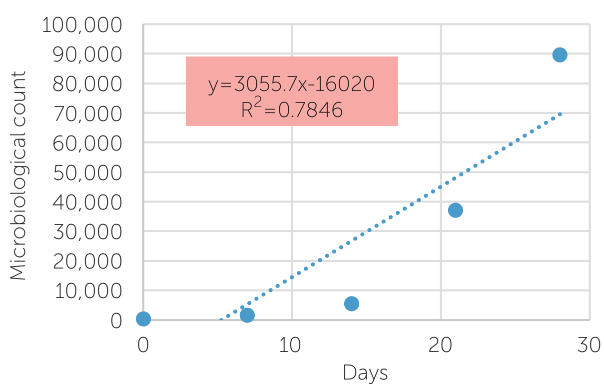

Figure 7. Linear correlation of smoked sausages acidity.

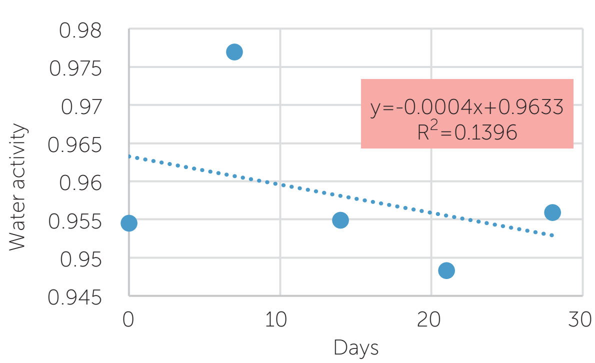

Figure 9. Linear correlation graph of the moisture percentage of smoked sausages.

Figure 7 indicates the linear correlation of the acidity behavior values of the product samples regarding time. The trend of the line indicates that the change in this parameter is small (value of the correlation factor), therefore, this variable is not a limiting factor for the product's shelf life.

Figure 8 shows the trend of the results of the water activity analysis determined to the smoked sausage samples.

There is no significant change in the correlation factor in the results, so it will not limit the shelf life of the product. Figure 9 shows the behavior of the results of the moisture percentage analysis applied to the smoked sausage samples.

According to the correlation factor, the moisture of the sausage is a factor that limits its shelf life, so it was analyzed this value, according to humidity values and its interrelation with time (Figure 10).

$$t = \frac{A_e - A_o}{k}$$

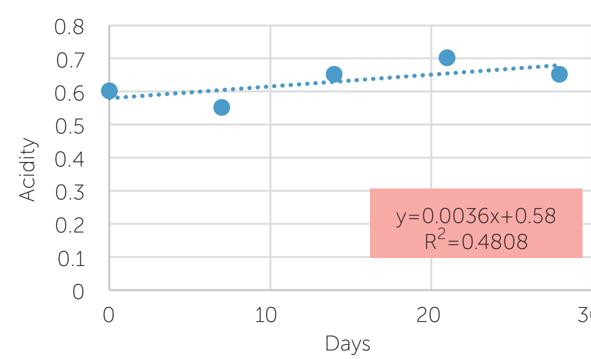

Figure 8. Linear correlation of the water activity of smoked sausages.

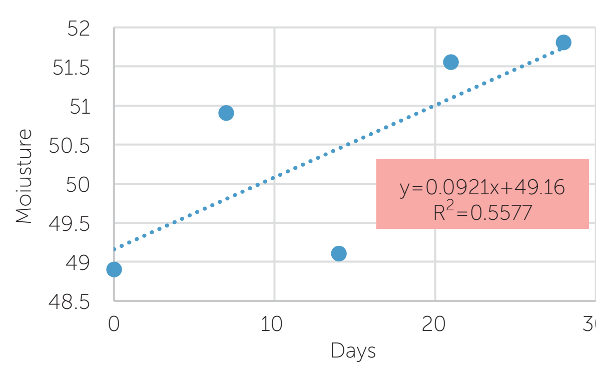

Figure 10. Linear correlation of microbiological analysis of smoked sausage.

$$t = \frac{55 - 49.16}{0.5577}$$

t=63 days of shelf life for the smoked sausages.

Table 6 shows the results of the aerobic mesophilic analyses performed on the smoked sausage samples.

Microbiological growth in the samples of the natural sausages was a limiting factor in this product, for which reason its shelf life was calculated. For this purpose, the slope and intercept data were obtained, and the maximum value of 200,000 CFU/g of aerobic mesophiles was used.

$$t = \frac{A_e - A_o}{k}$$

$$t = \frac{200{,}000 - 16020}{3{,}055.7}$$

t=71 days of shelf life for the smoked sausages.

The values of shelf life of the product in relation to the results of the analyses performed on the smoked sausage are obtained from an average to determine the value in the study, as shown in Table 7.

Table 6. Microbiological results of smoked sausages.

Storage days	Microbiological count (UFC*/g)
0	300
7	1,500
14	5,500
21	37,000
28	89,500

With these data, a linear regression graph was made (Figure 10).

Table 7. Results of the days of shelf life of smoked sausages.

Evaluated parameters	Shelf life (days)
pH	34
Moisture content (%)	63
Microbiological count	71
Average value	56

CONCLUSIONS

The natural sausage reported exhibited changes in physicochemical parameters, which could be seen in its appearance since it suffered water loss due to the small number of additives for water retention. As for their sanitary quality, standard NMX-F-065-1985 specifies a maximum limit of 500,000 CFU/g, it was decided to use a limit of 200,000 CFU/g, given that it is desirable to offer a higher quality than that of commercial sausages. With these parameters, a shelf life of 33 days was determined for the natural sausages, stored in refrigerated conditions (4 °C) in vacuum bags. The smoked sausages were processed in a similar way to the natural sausage; however, their cooking is done it was conducted with dry heat while the natural smoking process is done with particular woods. Therefore, the physicochemical parameters such as water activity and humidity are not affected and their sanitary quality is better than the natural sausage, which increases the product's shelf life to 56 days. In the natural sausages, due to the physical quality of the products in its packaging, it is also proposed to use an additive that retains water in the system and improves this undesirable aspect for the consumer. Due to this modification, it will be necessary to perform the shelf-life estimation in the future.

REFERENCES

Alvarez Calvache F., Santamaría D., Lara A. (2016). Análisis del tiempo de vida útil en la elaboración de mermelada de higuerón (*Cucúrbita Odorífera* Vell) con zanahoria (*Daucus Carota*). Revista chilena de nutrición, 43 (3), http://dx.doi.org/10.4067/S0717-75182016000300009

Carrillo Inungaray M.L., Reyes Munguía A. (2013). Vida útil de los alimentos. Revista Iberoamericana de las ciencias biológicas y agropecuarias. 2 (3).

FAO (2014). Departamento de agricultura y protección al consumidor. Consumo de carne.
www.fao.org/ag/againfo/themes/es/meat/background.html

FAO (2014). Departamento de agricultura y protección al consumidor. Grupo de productos.
www.fao.org/ag/againfo/themes/es/meat/Processing_product.html

FAO (2014). Departamento de agricultura y protección al consumidor. Tecnologías de elaboración.
www.fao.org/ag/againfo/themes/es/meat/Processing_techn.html

García Valencia F. E., Millán Cardona L. J., Jaramillo Garcés Y. (2008). Estimación de la vida útil fisicoquímica, sensorial e instrumental de queso crema bajo en calorías. Revista Lasallista de Investigación. 5 (1), pp. 28-33.

Giraldo Gómez I. (1999). Métodos de estudio de vida de anaquel de los alimentos. Universidad Nacional de Colombia.

González González G., Pirovani M. E., Piagentini A.M. (2016). Cinética de cambios sensoriales y vida de anaquel de carambola mínimamente procesada. Revista fitotecnia mexicana, 39 (4).

Prandal, O., Fisher A., Schmidhofer T., Jurguen H. (1992). Tecnología e higiene de la carne. Ed. Acribia. España.

Wirth F. (1999). Tecnología de los embutidos escaldados. Ed. Acribia. España.