

## Determination of shelf life by accelerated tests in banana preserves

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**Abstract:** Food degradation is an important tool for developing of new products in market and predicting its shelf life but for banana preserves, this is not efficient using traditional methods, so for these products shelf life accelerated tests (SLAT) are used. In this study objective was to determine shelf life of banana preserves with or without potassium sorbate using SLAT. For instrumental analysis, effect of constant temperature on reaction speed did not fit to Arrhenius model. Sensorial analysis results (flavor and global feature) fitted to Arrhenius model, allowing adjust to zero order model and prevision of shelf life of 125, 163 and 213 days for sweets without potassium sorbate stored to 40, 30 and 20 °C, respectively. For potassium sorbate shelf life prevision was 85, 127 and 193 days when stored to 40, 30 and 20 °C respectively.

**Keywords:** Sensorial analysis, Potassium sorbate, Food degradation.

## Determinação da vida de prateleira por testes acelerados de doce em massa de banana

**Resumo:** O estudo da degradação de alimentos constitui-se ferramenta importante para o lançamento de produtos no mercado e previsão de sua vida útil, sendo que produtos como doces em massa possuem vida-de-prateleira prolongada inviabilizando sua determinação por métodos convencionais levando à utilização de testes acelerados de vida-de-prateleira (TAVP). O objetivo desse estudo foi determinar a vida-de-prateleira de doce em massa de banana prata com e sem adição de sorbato de potássio através de TAVP. Para as análises instrumentais o efeito da temperatura na constante da velocidade de reação não se ajustou ao modelo de Arrhenius. Já resultados da análise sensorial (atributos de sabor e aspecto global) se ajustaram ao modelo de Arrhenius, permitindo também o ajuste ao modelo de reação de ordem zero e estimativa de vida útil de 125, 163 e 213 dias para os doces sem adição de sorbato de potássio armazenadas a 40 °C, 30 °C e 20 °C respectivamente, enquanto que, para os doces com adição do conservante, o tempo estimado de vida-de-prateleira foi 85, 127 e 193 dias quando armazenados a 40 °C, 30 °C e 20 °C respectivamente.

**Palavras chave** Análise sensorial, Sorbato de potássio, Degradação de alimentos.

## Introduction

Banana production in Brazil is distributed throughout the national territory, but it has increased production in the Northeast (39.15%), followed by the Southeast, South, North and Midwest with 31.7%, 13.5%, 11.8% and 3.5%, respectively (Silva et al., 2013a). According to Siqueira (2014) post-harvest losses of bananas in Brazil can reach 40%, and one of the causes is the lack of fruit conservation technologies. The investment in edge technologies for the conservation of the fruit would reduce post-harvest losses and could give Brazil a greater share of exports of the fruit.

Fruits preserves are resulting of appropriate processing of eatable parts of vegetable added by sugars, pectin, and pH adjusting besides other allowed additives until reach adequate consistency (Dias et al., 2011 & Santos et al., 2013). It can be added preservative additives, which are substances that retard deterioration processes of food products, protecting them from microorganisms and enzymes actions increasing their shelf life. Potassium sorbate in this case acts as efficient preservative that inhibits growth of microorganisms, has low toxicity for mammals, and causes less residual effect in flavor (Menezes, 2008).

Accelerated tests of shelf life (ATSL) can be applied as an alternative for shelf life determination in less time. These tests consists in storage of interest product under environmental conditions that are defined and controlled according to accelerate transformation rates, and changes in quality of product and time to deterioration are observed until they are not appropriate for consuming (Labuza, 1984, Miguel et al. 2009, Mori, 2004, Netto, 2004, Vitali et al. 2004 & Rosa et al. 2011).

Analysis of chemical, physical and biological parameters of product during storage time can have statistical treatment that represents occurred changes. However for deterioration reactions kinetic and shelf life estimation should be considered quality features that are perceived for consumers as a function of time. These features are average of sensorial acceptance of product in a hedonic scale of nine points and this case their grades could be utilized as an acceleration factor with temperature ( $Q_{10}$ ) and

posterior estimation of shelf life, (Brazilian Chemical Engineering Association [ABEQ], 2008).

This work had an objective of shelf life determination in banana preserves with or without potassium sorbate addition through accelerated tests.

## Material and methods

### Processing of sweeties preserves

Bananas were acquired from local market in Lavras, MG and transported for Pilot Plant of Vegetable Processing of Federal University of Lavras [UFV].

Fruits were washed with water and soap and immersed in aqueous solution of hypochlorite in concentration of  $200 \text{ mg L}^{-1}$  of solution during 15 minutes. After they were selected and peeled and blanching ( $100 \text{ }^\circ\text{C}$  for 5 minutes), posteriorly the pulp was removed in a pulp remover and a sample was taken for characterization analysis (Menezes, 2008). The peroxidase is considered the vegetable enzyme more stable to heat, it is responsible for browning in fruits, vegetables and their processed products and the inactivation of this enzyme has been used as an indicator of bleaching (Freitas et al., 2008). Banana preserves was obtained by using crystal sugar, pectin of high level of methoxylation and specification degree (USA-SAG 150) previously dissolved in water then mixed with pulp and concentrated in open recipients in temperature about  $85 \text{ }^\circ\text{C}$  until reaches  $74 \text{ }^\circ\text{Brix}$ . These sweeties were prepared with or without potassium sorbate. Formulation was 60% of sugar, 40% of pulp and 0.4% citric acid and this percentage is related to pulp mass. Acid was added half in the beginning of processing and other half at the final of processing because of recipient is open and high level of temperature that could cause pectin hydrolysis. In sweeties added of preservative potassium sorbate was added at the end of process in 0.1% of concentration (m/m related to initial pulp mass). Final product was bottled at hot in polypropylene packages, sealed and cooled at environmental temperature.

After processing and packaging banana preserves was storage in chambers with controlled temperature at 20, 30 and  $40 \text{ }^\circ\text{C}$  and not controlled relative humidity of 85% during 165

days for evaluate of influence of temperature variation of storage and potassium sorbate presence over physical, physical chemistry and microbiological characteristics of banana preserves during storage.

#### Attendance to shelf life

Analysis of total soluble solids, reducing and non-reducing sugars, color, texture analysis and acceptance tests were made.

Determination of total soluble solids was made by refractometer according to analytical tests of Adolfo Lutz Institute [IAL] (2008) and values were expressed in °Brix. Total sugars, reducing in glucose and non-reducing in sucrose was analyzed by Nelson (1944) and Somogyi (1945) method. Color of banana preserves was determined, in triplicate, according to Giese (1996) methodology which values of L\*, a\* and b\* was determined by a colorimeter Minolta model CR 400 working with D65 (day light) and using patterns CIELab.

Texture profile was analyzed by using a texturometer TA TX2i Stable Micro Systems, (Goldaming, England) in sweet samples with volume of 1 cm<sup>3</sup> with a cylindrical probe with flat bottom (4.5 cm) and time, distance, pre-test, test and post-test speeds of five seconds, 0.6 cm, 0.2 cm/s, 0.1 cm/s and 0.2 cm/s, respectively and tests was made in eight replicates. Obtained results from curve strength versus time were calculated by Texture Expert Version 1.22 software and parameters like hardness, cohesivity, elasticity and adhesiveness were analyzed.

For attendance of shelf life through sensorial analysis of samples were made tests of acceptance, color, flavor and global feature according methodology described by Della Modesta (1994) using hedonic scale with nine points which (1) dislike extremely, (5) neutral and (9) like extremely, applied to 50 not trained tasters. Samples were presented in monadic form randomized, coded with three digits numbers and tests were made in individual cabinets under white light according to a complete balanced block design. For kinetics of banana preserves deterioration study through sensorial data, it was adopted as maximum loss of quality grade neutral (5) in sensorial scale, called cut grade in this study.

#### Accelerated tests

For shelf life estimative was determined from shelf life attendance, sequentially, order of deterioration reactions, constant of reaction speed (k), activation energy and factor of temperature acceleration Q<sub>10</sub> through color and objective texture as well as sensorial results.

Reaction order was determined according to methodology described of Teixeira et al., (2004) following this protocol:

1. A graphic is plotted, linear scale, variable in function of time, if data adjust to a straight that presents a good R<sup>2</sup> (coefficient of correlation that varies from 0 to 1, better adjustment is near 1) so studied reaction is from zero order;

2. A graphic is plotted, monologarithmic scale, variable in function of time, if data adjust to a straight and a good coefficient of determination (R<sup>2</sup>) is presented so studied reaction is first order.

3. A graphic is plotted, linear scale, inverse of parameter in function of time, adjusting data to a straight; R<sup>2</sup> is above 0.5, so a second order is presented.

After find order of reaction, straight tendency value of constant of reaction speed (k) is indicated for each level of temperature.

Effect of temperature on the constant of reactions speed was described according to Arrhenius model. Activation energy (E) of reaction and Q<sub>10</sub> value were calculated to equations:

$$\ln k = -\frac{E}{R} \left( \frac{1}{T} - \frac{1}{T_0} \right) + \ln k_0 \quad (1)$$

E = activation energy (kcal/mol);

T = absolute final temperature;

T<sub>0</sub> = absolute reference temperature;

k = constant of reaction speed.

$$Q_{10} = 10^{\frac{E}{0.46RT^2}} \quad (2)$$

T = K in temperature

E = Kcal mol<sup>-1</sup>

Shelf life estimative was calculated, first of all, through equation (y= a + bx) generated by adjustments, in the regression for temperature of 40 °C adopted cut grade for sensorial 5 and x as an estimative value for shelf life, and after it was utilized temperature acceleration factor (Q<sub>10</sub> – equation 2) which shelf life value in 40 °C was multiplied to Q<sub>10</sub> value to estimate shelf life value in temperature of 30 °C that was multiplied to Q<sub>10</sub>

for determination of shelf life in 20 °C too. The parameters and the graphs were plotted by Excel software 2007.

## Results and discussion

Despite of alterations occurrences of some physic and physic chemical variables during storage, temperature effect in constant reaction speed do not adjust to Arrhenius model that is accepted model to represent effects of accelerated temperature conditions (Teixeira et al., 2004) presenting low values of  $R^2$  plotted in linear scale,  $\ln$  of constants of temperature acceleration versus inverse of absolute temperature,  $R^2$  is determination coefficient that indicates quality of accomplished adjustment. This coefficient varies from 0 to 1 and if it's near to zero worse is adjust and lesser is number of explained cases which a variable explains others (Johnson & Bhattacharyya, 1997).

Teixeira et al., (2004) assert that Arrhenius Model is a mathematical model in function of temperature, which means that do not describe alterations made by other processes. In this study, some physical chemical alterations may occur by other factors not only for time and for temperature. Faria (1990) and Vitali et al. (2004) describe that Arrhenius equation allow an estimative more accurate of shelf life but if it is impossible to use it and with information about changes of parameters physical chemical it can base model in sensorial data.

Texture and color attributes do not achieve cut grade until evaluated time in all treatments for kinetic determination of deterioration of banana preserves according to which was observed on objective evaluation of texture and color. So data do not allowed kinetic of deterioration study. Flavor presented cut grade in 75 days of storage while global feature just achieve this grade in last time of evaluation and this behavior occurred as much as for treatments with potassium sorbate and without preservative addition. Similar results were observed for Miguel et al. (2009), Dias et al., (2011), Silva et al., (2013b) and Hansen et al.,

(2013).

Experimental results for attributes degradation of flavor and global evaluation during storage on temperatures of 20, 30 and 40 °C are shown in (Figures 1 and 2). As it was observed, all reactions adjust to kinetic model of zero order generating a good determination coefficient ( $R^2$ ) for adjusted model. This behavior is common in food (Teixeira et al., 2004). Similar results were observed in guava for Moura et al., (2011).

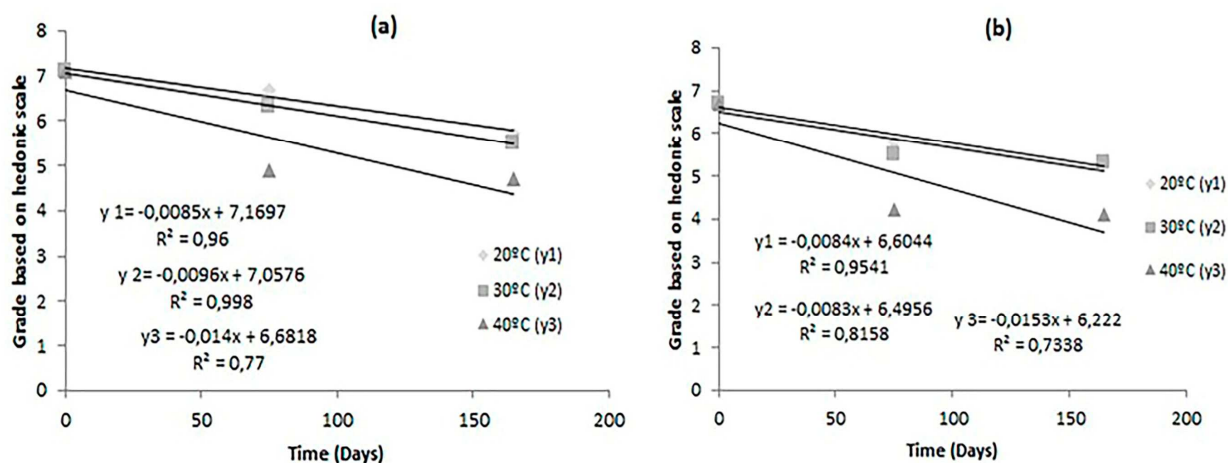
Through regression equation (Figures 1 and 2) it was determined that in temperature of 40 °C attributes of flavor and global feature of banana preserves with no potassium sorbate achieve cut grade about 120 and 130 days of storage, respectively. In other temperatures (20 and 30 °C) cut grade was not achieve during study period.

For bananas preserves with potassium sorbate it was verified a good adjust to reaction model for zero order which  $R^2$  varied from 0.73 to 0.95 (Figures 1 and 2). It is observed a pronounced decrease in sensorial quality of product in temperature of 40 °C that presented cut grade by regression equation for attributes of flavor and global features in 79 and 91 days of storage, respectively.

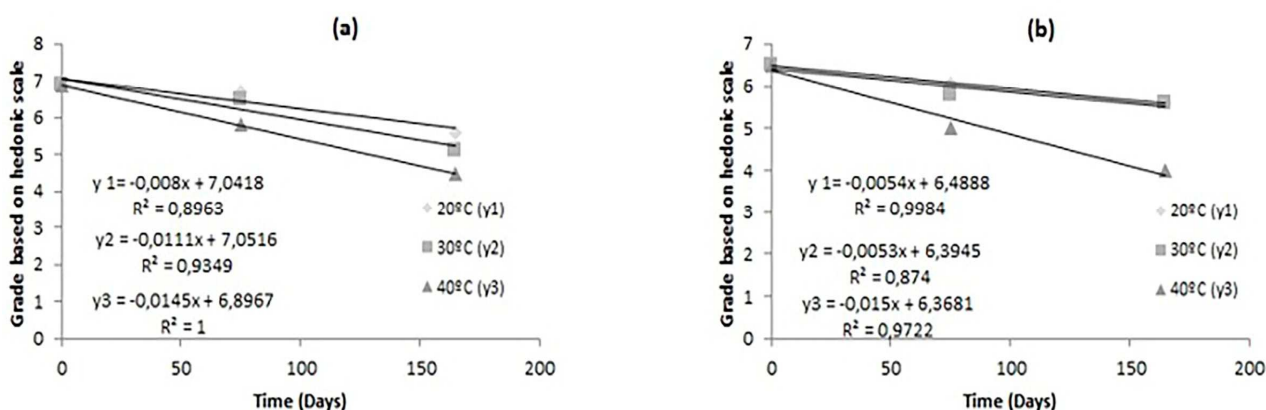
Energy activation values ( $E_a$ ) for attributes of flavor and global features calculated from adjusts of Arrhenius model (Figure 3) are in Table 1.

Banana preserves with no potassium sorbate presented activation energy values lower than those with preservatives that indicates less quantity of activation energy is needed to unleash reaction. However, banana preserves with potassium sorbate achieved cut grade faster than treatments with no preservative. Similar results were described for Menezes (2008) with guava sweets with and without potassium sorbate and Rosa et al. (2011) with pineapple jelly. Author observed that sweets with preservative presented low scores in less time than other with no preservative.

**Figure 1** - Kinetic model for changes in flavor of banana preserves: (a) With no potassium sorbate and (b) With potassium sorbate.



**Figure 2** - Kinetic model for changes in global feature of banana preserves: (a) With no potassium sorbate and (b) With potassium sorbate.

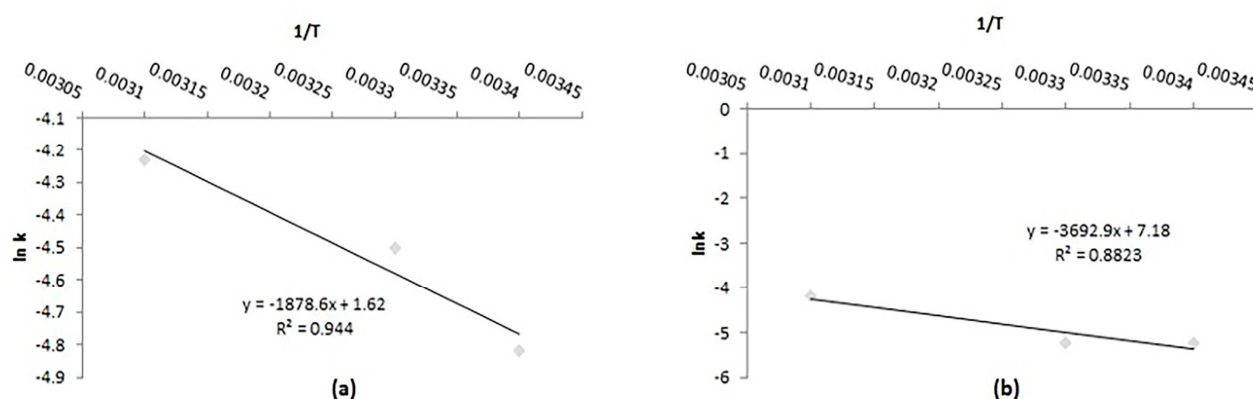


Value of  $Q_{10}$  (Table 1) was calculated through equation 2. Values of  $Q_{10}$  for sweets are little described in literature but for products like strawberry pulp, raisin apple, dried apple, strawberry jelly, guava jelly as much as dehydrated products in general this factor is largely studied and presents values next to 2 value above those found out on this study (Labuza, 1982, Miguel et al. 2009, Moura et al., 2007, 2011 & Vitali et al. 2004).

Definition of  $Q_{10}$  indicates that for each 10 °C of decrease of storage temperature of sweets time of shelf life is multiplied to  $Q_{10}$  value. According to this definition and in shelf life value that was calculated previously, for sweets stored in temperature of 40 °C it can be estimated values of shelf life of sweets in temperatures of 20 °C and 30 °C (Table 1) for each attribute.

**Table 1** - Activation energy and Estimative of shelf life of banana preserves.

Treatments	Attributes	Activation energy (Ea) kcal/mol	Q <sub>10</sub>	Estimative of shelf life	
				30 °C	20 °C
Banana preserves with no potassium sorbate	Flavor	4.4525	1.27	152	193
	Global feature	5.424	1.34	174	233
Banana preserves with potassium sorbate	Flavor	5.411	1.34	105	140
	Global feature	9.221	1.65	150	247

**Figure 3** - Arrhenius graphic for global feature attribute of banana preserves: (a) With no potassium sorbate, (b) With potassium sorbate.

Time of shelf life estimated for banana preserves cv. prata with or without preservative is according to period of time of shelf life described for Tfouni and Toledo (2002) for sweets stored in temperature 25 and 30 °C between six months and one year. Author notice that this time can be prolonged by processing and storage conditions of product that justify shelf life value estimated for banana stored in 20 °C. Similar results were observed for lichia fruit stored at different temperatures (Ramos et al., 2011).

Banana preserves with potassium sorbate presented an average time of shelf life of 127 days in 30 °C and 193 days in 20 °C while those with no preservative presented average values of shelf life of 163 days in 30 °C and 213 days in 20 °C. It was observed that treatment with preservative presented lesser values than those

with no preservative in all storage temperatures. According to Vidyasagar and Arya (1984), however sorbic acid and its salts are stable in dried and pure formulation (Mccarthy & Eagler, 1976) in aqueous solution suffers an oxidative degradation becoming malonaldehyde and other hydro carbonates. These compounds can carry on to browning and being responsible for changes in quality and acceptance of food products.

Sorbic acid and its potassium salts are crystalline solids in environmental temperatures presenting solubility in water above 50% in that temperature (Thakur et al., 1994) however despites of high temperatures of cooking salt could be dissolved partially and its remaining crystals potentiate a nucleation phenomenon. It can be occurred a condensation of material due to supersaturating of medium and particle collision

and stable nucleus formation. According to McCabe et al. (1993) after occurrence of this phenomenon, material tends to crystallize. This fact can be observed in this study 165 days after storage, mainly in sweeties with potassium sorbate, which can affect taster judgment. This behavior is important for future works in attendance of nucleation phenomenon during period of study of shelf life.

## Conclusions

According to the estimated shelf life in this work, it is concluded that the addition of potassium sorbate as a preservative did not increase the shelf life of banana preserves.

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