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A STUDY OF STOCHASTIC MODEL TO PREDICT THE GROWTH EVOLUTION OF FOOD BORN MOULDS

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Abstract

Over the last few decades stochastic study in biology has acquired global dimension. The prevention of the food product contamination with toxinogenic moulds is an actuality problem of microbiology. This means that it is necessary to have precise diagnostic methods in order to predict and describe in detail the dynamic of the alteration. Considering all these facts, we tried to develop in our paper a stochastic model to answer to this question. First, we have established some conclusions regarding the growth model; for this, we have made appropriate graphics corresponding evolution strains of Penicillium crysogenum and Fusarium graminearum during the 14 days. Secondly, we have examined the phenomenon of growth as a non-homogeneous Poisson process involving periodic variations in the occurrence rate and we have obtained the probability density function of the time intervals of growth.

Keywords: *food born moulds, random variable, stochastic model.*

INTRODUCTION

It is known that health is the top priority for all of us and that a balanced life that includes a proper diet leads to this goal. Starting from this consideration to justify growing interest of many researchers in biology, agriculture, medicine and food to ensure a healthy diet to include foods that meet certain nutritional parameters and are of course unaltered. Prevent food contamination with moulds toxin is thus a continuing concern of specialists in the fields mentioned above.
In [1] state that accurate methods are required to indicate detailed description of the dynamics of food spoilage. Deterministic mathematical modelling is a technique that we used for to present the growth and evolution of food born moulds is described in [4].
First, there have been isolated and identified the main species involved in the alteration of food products of intermediary activity. The strains have been screened for their toxinogenic activity by on-plate method and the toxins are quantified by Elisa Immunologic tests. From this collection four strains (Fusarium Graminearum MI 107 and MI 113 and Penicillium crysogenum MI 210) have been studied for their growth and mycotoxin (DON and OTA) production from a predictive point of view, depending on the environmental condition.
Since when analyzing the evolution mycelia growth rate are involved and random physical aspect, we intend to study this problem by applying stochastic modeling.

MATERIAL AND METHOD

2.1. Microorganisms

The *P.chrysogenum MI 210* and *F.graminearum MI 113* strains, established as potential producers of ochratoxin, respectively DON, were considered for this experiment to watch and compare the rate of their growth in various conditions of temperature.

Before use, all strains were activated by successive passages on the average PDA for 7 days of culture at 27 ° C. The spores were harvested in a solution of water physiologic sterile (9 g / l of NaCl) going from the two strains of *Penicillium sp*. and *Fusarium sp*., through the scraping light area of colonies with a Pasteur pipettes.

The inoculation was done in the center of boxes with Petri Czapek-Dox in duplicate for each strain taken in work. On environment Czapek-Dox, it tried to follow mycelia growth (growth in cm.), for a strain of *Penicillium crysogenum (MI 210)* and one *of Fusarium graminearum (F. graminearum MI113).*

The samples have been studied in triplicate, under different temperature conditions (4° C, 12° C, 16° C, 20 ° C, 26° C, 30°C, 33° C, 36° C)

2.2. Deterministic modelling

In order to establish some conclusions regarding the growth model to determine which estimates best the studied situation, are made appropriate graphics corresponding to the development strains of *Penicillium crysogenum* and *Fusarium graminearum* during the 14 days that measurements were made, at certain temperatures. It is originally indicated, in accordance with graphics obtained, mathematical curves that estimates best studied phenomenon, namely primary model. It made such a development for *Penicillium crysogenum*, at temperature T = 30 °, as indicated rate of growth within 24 hours. In the next step is verified the growth model's plausible for the species *Pencillium crysogenum*.

Because the analysis period, the evolution phenomenon presents a continuous growth, the empirical points curve presents a form that can be estimated depending logarithmical function, the model that can be used for the evolution of the phenomenon is an approximation of the form:

$$y_t = f(t) + u_t \qquad (1)$$

where:

y_t = the recorded values during the period examined phenomenon

$f(t)$ = the trend component that can be described with a logarithmical functions: $Y_t = f(t) = a + b * \ln t$ u_t = the residual variable.

2.3. Stochastic modelling

The Poisson process is considered the easiest of discontinuous Markov processes. Due to the wide applicability in areas such as biology, physics, technology, telecommunications, transportation, and so on, this process has a special place in probability theory.

It considers the following postulates for Poisson processes:

1) For the process $X(t)$ probability to have a change in time $(t, t+\Delta t)$ is $\lambda t + 0(\Delta t)$ where a given positive constant is λ.

2) The probability to occur over a change in $(t, t+\Delta t)$ is $0(\Delta t)$.

3) The probability to have been no change in the time $(t, t+\Delta t)$ is $1 - \lambda t - 0(\Delta t)$.

These probabilities are independent of system states [2].

Let us note:

$$p_x(t) = P(X(t) = x), x \in N \qquad (2)$$

Then,

$$p_x(t+\Delta t) = P(X(t+\Delta t) = x) =$$
$$(1-\lambda\Delta t)\, p_x(t) + \lambda p_{x-1}(t)\Delta t + 0(\Delta t) \quad \Rightarrow$$
$$p_x(t+\Delta t) - p_x(t) = -\lambda \Delta t p_x(t) + \lambda p_{x-1}(t)\Delta t + 0(\Delta t) \qquad (3)$$

If we divide this last relationship to Δt and then move to limit $\Delta t \to 0$ follows:

$$\frac{dp_x}{dt} = -\lambda p_x(t) + \lambda p_{x-1}(t), x \geq 1 \qquad (4)$$

if $x = 0$, $p_{x-1}(t) = 0$ $\frac{dp_0}{dt} = -\lambda p_0(t)$ (5)

Equations (4) and (5) are the equations that characterize the Poisson process [3]. Their resolution is based on the initial condition:

$$p_x(0) = \begin{cases} 1, x = 0 \\ 0, x \in N^* \end{cases} \qquad (6)$$

The expression:

$$p_x(t) = \frac{(\lambda t)^x}{x!} e^{-\lambda t} \qquad (7)$$

is Poisson distribution, and it gives the probability that at time $t \geq 0$, the system to be

in state x. Relation (7) can be interpreted as the probability that changes occur within the length t.
The number of events in an interval of length t is Poisson distributed with mean and variance

$$E\left(X\left(t\right)\right)=Var\left(X\left(t\right)\right)=\lambda\cdot t \qquad (8)$$

A *random graph* is obtained by starting with a set of *n* vertices and adding edges between them at random [1]. A random graph G_t for a stochastic process $X\left(t\right)$ has not only a time dimension, but also a spatial dimension. At any snapshot at time *t*, one observes a realization of a random graph G_t

RESULTS AND DISCUSSIONS

The development strains of *Penicillium crysogenum* and *Fusarium graminearum* is a continuous process. At T = 26 ° C, the first determination of Penicillium crysogenum-day 1 to day 13-a, period in which the effect of increasing strain-linear growth. Before use, all strains were activated by successive passages on the average PDA for 7 days of culture at 27 ° C. The spores were harvested in a solution of water physiologic sterile (9 g / l of NaCl) going from the two strains of *Penicillium sp.* and *Fusarium sp.*, through the scrapeing light area of colonies with a Pasteur pipettes. The analysis of the results and the determination the type of curve after which the moulds growth in the initial experience, it has been made both for *Penicilium crysogenu*m as well as for *Fusarium graminearum* with package programs Eviews.

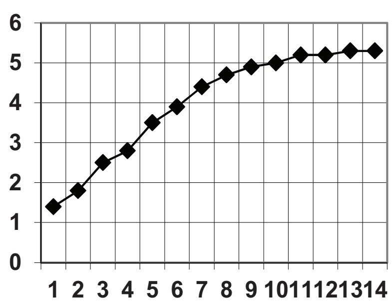

Fig. 1. The growth (cm) of *Penicillium crysogenum*

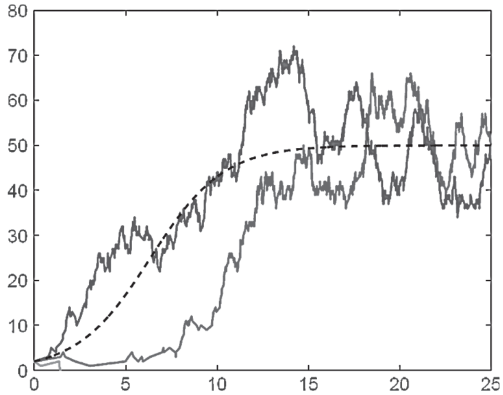

Fig. 2. The growth (mm) of *Penicillium crysogenum* - random Graph

The second measurement for Penicillium chrysogenum, from day 2 to day 12-a period in which the effect of increasing strains

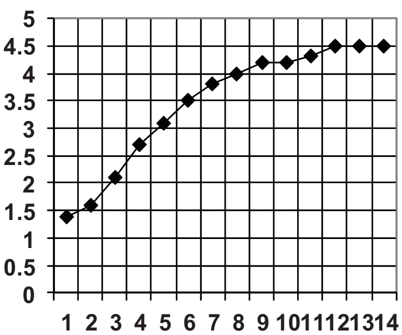

Fig. 3. The growth (cm) of *Penicillium crysogenum*

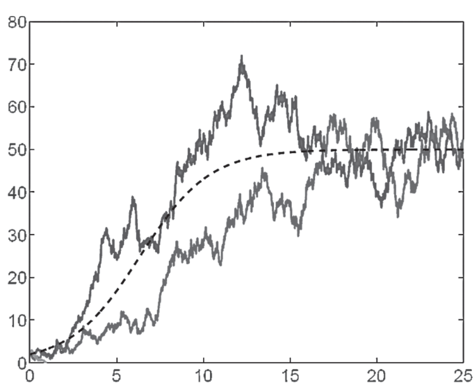

Fig. 4. The growth (mm) of *Penicillium crysogenum* - random Graph

CONCLUSIONS

In this paper, we have established some conclusions regarding the growth model of food born moulds. We have made appropriate graphics corresponding evolution strains of Penicillium crysogenum and Fusarium graminearum during the 14 days and we have examined the phenomenon of growth as a non-homogeneous Poisson process involving periodic variations in the occurrence rate and we have obtained the probability density function of the time intervals of growth. If we denoted $X(t)$ the growth of food moulds at time t, then, the probability distribution of this process is a Poisson distribution.

REFERENCES

[1] Brauer F., Driessche P., 2008. *Mathematical Epidemiology*, Springer- Verlag, New York p. 241-248

[2] Leah E., 1988. *Mathematical Models in Biology*, Random-House, New-York, p. 115-120.

[3] Rosemblatt M., 1974. *Random Processes*, Springer-Verlag, New York, Berlin, p. 66-80.

[4] Varga M., Matei F., 2009. *The application of statistical modeling tools to predict the growth evolution of foodborn moulds,* Romanian Biotechnological Letters, Bucharest, 0,152 p.4249-4259.