THE INFLUENCE OF THE DRYING AGENT'S PARAMETERS IN CEREAL DRYING PROCESS

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ABSTRACT: This paperwork shows some observations and conclusions regarding the necessity of technical methods utilization for preservation of cereal products by cooling systems, in the meaning of efficient storage activities and preservation of cereals, of keeping the standards for quality and nutritional safety in the present context of integration in the great European family.

Cuvinmte cheie:

REZUMAT: Procesul de uscare al cerealelor este un proces complex, insuficient studiat, datorită unor dificultăţi care apar la cercetarea diferiţilor parametri ce influenţează procesul de uscare. Algoritmul procesului de uscare a cerealelor, descrie evoluţia în timp sau după anumite dependenţe reciproce, în condiţiile existenţei unor factori externi cunoscuţi sau determinaţi experimental. La

stabilirea modelului matematic, pentru uscarea cerealelor s-a avut în atenție identificarea unor ecuații de uscare pentru câteva tipuri de cereale.

Keywords:

1. INTRODUCTION

Cereals represent the most important feed for humans. According to FAO information, each year over 20% of the gathered cereals are lost on a worldwide scale [6]. The largest part is due to pest activity, development of fungus and mildew [2, 4[.

Each year over 60 million tons are wasted through mildew process due to inadequate depositation. The detailed analysis of the existing dryers in exploitation shows that their operation can be improved through equipping them with monitoring and command systems, run from a computer, on the basis of programming of one or more parameters, function of the modifications of input data. Designing of a system that allows automatic adjustment of the temperature in a drying installation dictate the knowledge over a complex of parameters, of which interdependence is expressed through criteria equations of different shapes.

2. NEW ASPECTS CONCERNING CEREAL CONSERVATION

Usually, the experimental data are made from pairs of data (U_i, τ_i), in the case of dependencies of a single variable, or sets of data pairs (U_i , τ_i , t_i, ...), for the case of dependencies of more than one independent variables [1, 3]. Here, U is the humidity content, [%],τ – drying time, [minutes], t – temperature, [^{0}C]; i = 1, 2, 3, ... n -1, n – measurement number.

The problem consists in approximating the discrete dependencies U_i (τ_i) or U_i (τ_i, t_i) with continuous dependencies U (τ) or U (τ, t). There are three types of approximations:

- data interpolation and extrapolation;
- data regression;
- data filtration.

The method consists in determining the coefficient for the chosen class of functions, so, for modelling the drying process it will be selected the polynomial :

$$U(\tau) = a_0 + a_1\tau + a_2\tau^2 + \text{..........} + a_{N-1}\tau^{N-1} \quad (1)$$

The filtering techniques are applied for analyzing the signs for excluding the noise effects, meaning for functions that are intensively pendulos, so, for this type of application is preferable the experimental data regression. The regression consist in determining a function $U(\tau)$, that, in a certain way minimizes the deviations $\left|U_i(\tau_i) - U_i(\tau_i)\right|$. The success of this kind of approximation depends in a large way of the correct choice for the classes of functions. The most used classes are :

- polynomial,

$$U(\tau, A, B, C....) = A + B\tau + C\tau^2 + D\tau^3 + ... \quad (2)$$

- exponential,

$$U(\tau, A, B, C) = A \cdot e^{B\tau} + C \quad (3)$$

- logistic,

$$U(\tau, A, B, C) = \frac{A}{1 + B \cdot e^{-C\tau}} \quad (4)$$

- sinusoidal,

$$U(\tau, A, B, C) = A \cdot \sin(\tau + B) + C \quad (5)$$

- functions with powers,

$$U(\tau, A, B, C) = A \cdot \tau^B + C , \quad (6)$$

- logarithmic,

$$U(\tau, A, B, C) = A \cdot \ln(\tau + B) + C , \quad (7)$$

The purpose for regression is to calculate the parameters A, B, C. Those parameters are determined with the condition that the average of the square deviations sum to be minimum :

$$\Phi(\tau, A, B, C) = \frac{\sum_{i=1}^{N} (U_i - U(\tau_i))^2}{N} \to \min \ , \quad (8)$$

The functional Φ, will be :

$$\Phi = \sum_{i=1}^{n} (U_i - U_m(\tau_i))^2 , \quad (9)$$

The functional Φ, has a minimum value if :

$$\frac{\partial \Phi}{\partial a_i} = 0, \quad i = 0, m , \quad (10)$$

We obtain $m+1$ equations :

$$\sum \left(U_i - a_0 - a_1\tau_i - a_2\tau_i^2 - ....a_m\tau_i^m\right) \cdot \tau_i^k \ , \quad (11)$$

or

$$a_0 \sum_{i=0}^{n} \tau_i^k + a_1 \sum_{i=0}^{n} \tau_i^{k+1} + a_2 \sum_{i=0}^{n} \tau_i^{k+2} + ... + \\ + a_m \sum_{i=0}^{n} \tau_i^{k+m} = \sum_{i=0}^{n} U_i \tau_i^k , \quad (12)$$

note:

$$b_k = \sum_{i=0}^{n} \tau_i^k \quad , \quad c_k = \sum_{i=0}^{n} U_i \tau_i^k \ , \qquad (13)$$

and present the explicit system.

$$\begin{cases} b_0 a_0 + b_1 a_1 + b_2 a_2 + ... + b_m a_m = c_0 \\ b_1 a_0 + b_2 a_1 + b_3 a_2 + ... + b_{m+1} a_m = c_1 \\ .... \\ b_m a_0 + b_{m+1} a_1 + b_{m+2} a_2 + ... + b_{2m} a_m = c_m \end{cases} , \quad (14)$$

We obtained a system of $m + 1$ algebra unhomogeneous equations related with the coefficients $a_0 .... a_m$. It can be proven that the determinant of this system :

$$D = \begin{vmatrix} b_0 & b_1 & b_2 & ...... & b_m \\ b_1 & b_2 & b_3 & ..... & b_{m+1} \\ .... & ..... & ..... & & ...... \\ b_m & b_{m+1} & b_{m+2} & ... & b_{2m} \end{vmatrix} , \qquad (15)$$

named Gramm's determinant is not zero. So, the equation system has a single solution and with it is obtained the function $U(\tau)$ that gives the function Φ a minimum value [1, 3, 10].

3. MATHEMATICAL MODELLING OF THE CEREAL DRYING PROCESS

The conditions for cereal drying differ from a species to another, function of the final destination.

Those conditions are connected with the drying agent's temperature, the humidity and time of residence for the material in the dryer. Between those elements there exists a correlation of a complex form, that depends of a series of constructive and functional parameters for the dryer : the architecture of the drying chamber, the speed of the drying agent, the humidity of the drying agent, the way of circulation for the material related with the drying agent, etc.

For obtaining a maximum quality for seeds, it is necessary to be known and to be applied in each moment a dependency : drying agent temperature = *f*(seed humidity), where the form of a polynomial equation of 2nd degree :

$$T(\tau, U) = a_U \cdot U^2 + b_U \cdot U + c_U + a_\tau \cdot \tau^2 ,$$

where: T is the temperature for the drying agent [°C];

τ – the duration of the drying process [min];

U – humidity of the product [%];

a, b, c – constants that depend on the product and it's destination.

$$T_1(\tau_1, U_1) = a_U \cdot U_1^2 + b_U \cdot U_1 + c_U + a_\tau \cdot \tau_1^2 ,$$
$$T_2(\tau_2, U_2) = a_U \cdot U_2^2 + b_U \cdot U_2 + c_U + a_\tau \cdot \tau_2^2 ,$$
$$T_3(\tau_3, U_3) = a_U \cdot U_3^2 + b_U \cdot U_3 + c_U + a_\tau \cdot \tau_3^2 ,$$
$$T_4(\tau_4, U_4) = a_U \cdot U_4^2 + b_U \cdot U_4 + c_U + a_\tau \cdot \tau_4^2 ,$$

In figures 1 – 3, are presented the diagrams for the equations of the drying agent temperature for corn and grain seeds, designed for consume, and in figures 5, 7, for seeds, and also the graphic evolutions of those functions. Also in figures 2, 4, 6, 8, are presented the maximum temperatures of the drying agent for grain and corn seeds as a function of the product humidity and duration of the drying process.

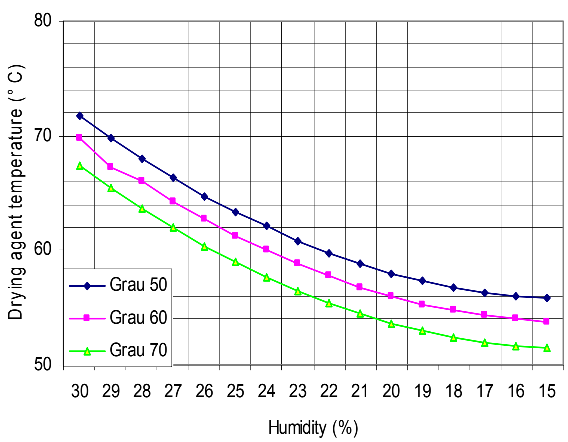

Fig. 1. Maximum temperature of the drying agent for consumable grain.

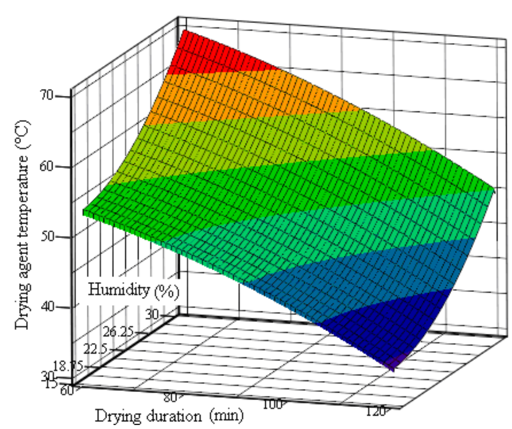

Fig. 2. Maximum temperature of the drying agent for consumable grain.

Consumable grain $T(\tau, U) = 0{,}062 \cdot U^2 - 1{,}75 \cdot U + 72{,}545 + 1{,}818 \cdot 10^{-3} \cdot \tau^2$

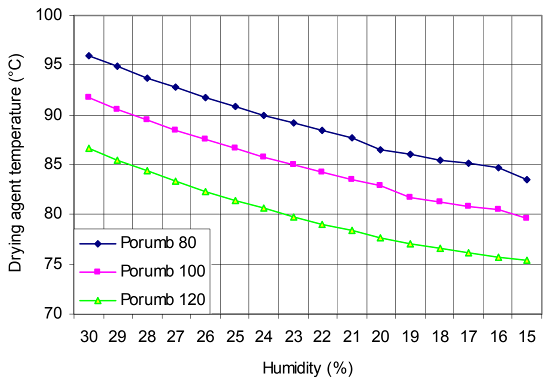

Fig. 3. Maximum temperature of the drying agent for consumable corn.

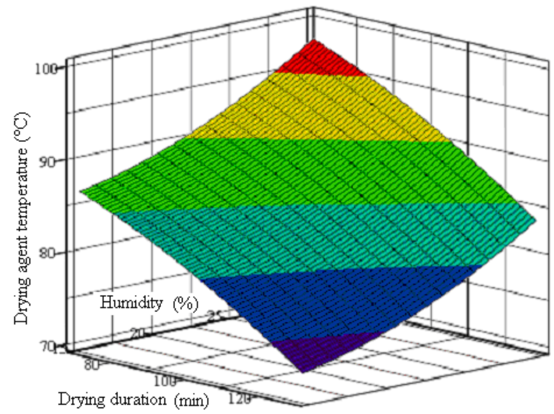

Fig. 4. Maximum temperature of the drying agent for consumable corn.

$$\textbf{\textit{Consumable corn}}\ (\tau, \mathrm{U}) = 0{,}028 \cdot U^2 - 0{,}5 \cdot U + 93{,}529 - 1{,}176 \cdot 10^{-3} \cdot \tau^2 ,$$

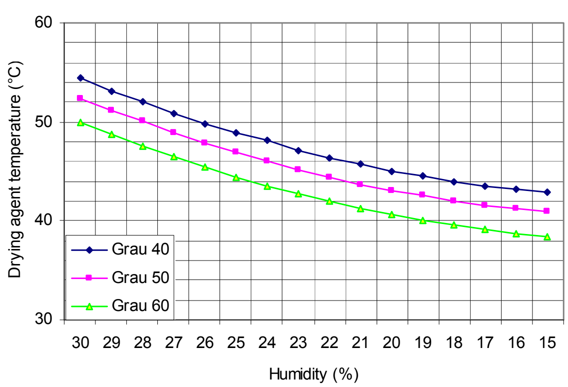

Fig. 5. Maximum temperature of the drying agent for grain seeds.

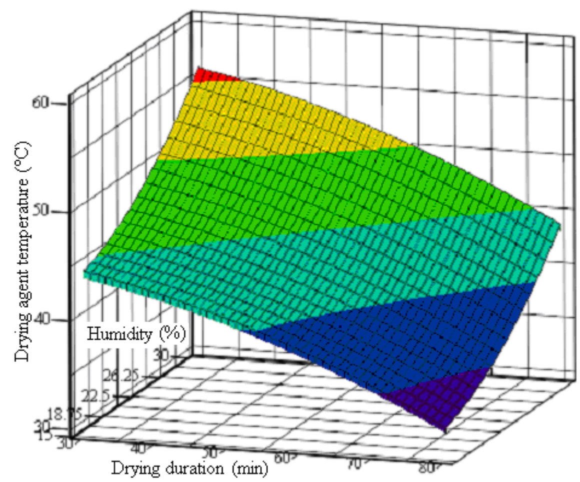

Fig. 6. Maximum temperature of the drying agent for grain seeds.

$$\textbf{\textit{Grain seeds}}\ T(\tau, U) = 0{,}033 \cdot U^2 - 0{,}733 \cdot U + 49{,}956 - 2{,}222 \cdot 10^{-3} \cdot \tau^2$$

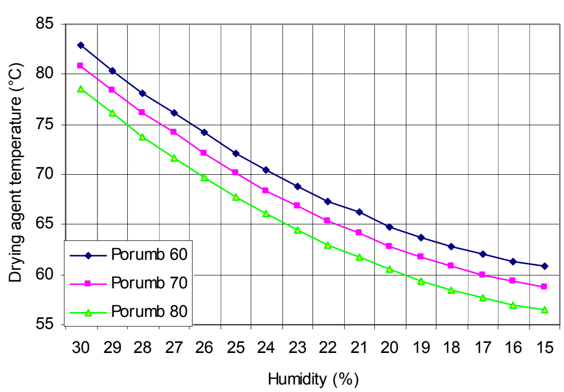

Fig. 7. Maximum temperature of the drying agent for corn seeds.

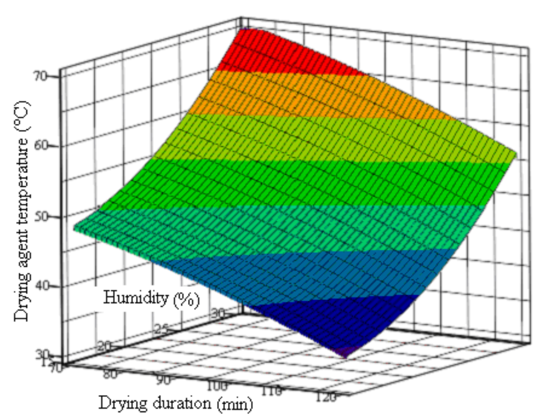

Fig. 8. Maximum temperature of the drying agent for corn seeds.

$$\textbf{\textit{Corn seeds}}\ (\tau, \mathrm{U}) = 0{,}067 \cdot U^2 - 1{,}533 \cdot U + 74{,}338 - 1{,}538 \cdot 10^{-3} \cdot \tau^2$$

4. CONCLUSIONS

After the analysis of the experimental data it can be observed that for the better conservation of the germinative quality of the grain seeds in the conditions of a constant thermal regime, in conditions of medium energetic demand, it is recommended a temperature of 80°C for the drying agent and a period of 55÷65 minutes, followed by a cooling of minimum 10 minutes. Also, for seeds destined for consumption it is recommended a constant thermal regime but with an increase of 10 – 15% of the drying agent temperature value.

Applying one aggressive regime (high values of the drying agent temperature, large duration time for drying, etc) can lead to depreciation of products (burning, roasting, etc), variation of the organoleptic and technological properties of the cereal.

For this, the application in a complete volume with a high level of quality for the drying and storing technologies in the analyzed case of the cereals can concur to the annulment / reduction of the unwanted effects with a large impact over the population.

The drying agent temperature value depends of the species and it's destination. The drying equations for the two sorts of cereal, gain and corn, for consumption and for seeds have a shape determined by the material characteristics (a, b, c), their destination, the temperature of the drying agent T, the duration for the drying process τ and the humidity for the product that has to be dried U.

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