REDUCTION INTERPOLATION FUNCTION FOR DETERMINING THE RHEOLOGICAL PROPERTIES OF BILE IN FARM ANIMALS TO INCREASE THE ENTREPRENEURIAL ACTIVITY OF THE AGRICULTURAL SECTOR

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ABSTRACT

Aim of the study: In this work, the density and viscosity of bile extract of cattle are determined experimentally, depending on the evaporation time, its humidity and temperature. These parameters are used to determine the optimal evaporation temperature for long-term storage of bile extract.

Methodology: During the experiment, an isothermal process occurs. Methods for interpolating experimental data with splines are considered. A computer program was developed for interpolating the bicubic spline function experimentally obtained values of density and viscosity depending on the time and humidity of the bile extract.

Conclusion: The interpolated results of the experiments are presented as graphs of spatial functions using the SURFER graphical editor.

Keywords: Entrepreneurship, Entrepreneurial Activity of the Agricultural Sector, Rheological Properties.

INTRODUCTION

Currently, new progressive methods of complex use and processing of by-products for both food and medical purposes are being introduced in the world practice. The use of by-products of livestock processing as raw materials for the production of organ preparations occupies a strong position in the domestic and foreign medical industry (Agricultural, 1965).

Effective use of by-products directly affects the economy and environmental pollution of the country. Non-use or under-use of by-products not only results in the loss of potential revenue, but also leads to the added and increasing cost of disposing of these products. Improper use of animal by-products can lead to serious aesthetic and catastrophic health problems (Dall'Acqua, 2018). In addition to the pollution and hazard aspects, in many cases, waste from meat, poultry and fish processing can process raw materials or turn into useful products of higher value. Regulatory requirements are also important because many countries restrict the use of meat offal for food safety and quality reasons (Francis, 2015).

The current level of development of the meat industry of agriculture requires a fundamentally new approach to the problem of integrated use of all types of products. In this regard, the utilization of by-products instead of their full and deep processing means not only the loss of valuable food and feed protein, but also huge monetary losses that lead to an increase in the cost of meat (Goodwin, 1992).

In the process of slaughter, butchering of large and small cattle and pigs, processing of slaughter products and production of meat products, industry enterprises receive not only the main product, but also up to 40 percent of by-products and waste (Henning, 1961). This category includes by-products that are not directed to food as the main raw material, blood, bone, skins, guts, raw fat, endocrine-enzyme and special substances, the contents of the gastrointestinal tract and non-food raw materials (Krebs, 1978). All this is used for the manufacture of certain types of food products, pharmaceuticals, feed and technical goods, leather, fur products, and others (Krugilin, 2018).

Equally important and useful is endocrine-enzyme and special raw materials that can be used for the manufacture of domestic medical and veterinary drugs for the prevention and treatment of a number of diseases (Krugilin, 2010).

However, the rate of use of such raw materials in Kazakhstan remains very low, and most of it is recycled. Effective use of bile and gallstone in primary training facilities can provide additional profit (Krebs, 1984).

METHODOLOGY

The choice of optimal technological parameters for freezing water extracts of bile depends on the temperature and mechanical effects on the product in the devices of food production (New Mexico, 2006).

To preserve the original biological properties of endocrine-enzyme and special raw materials, it is immediately preserved after collection and purification (Service Innovation in Agricultural Business, 2018). Choose such methods of preservation to prevent the development of microbiological processes and to the maximum extent to slow down the biochemical processes in the tissues (Vanderbilt, 1850).

Bile intended for storage should be preserved, as it quickly rots. For the production of medical products, freshly harvested bile from cattle is preserved by freezing, drying and thickening methods (Weyant, 1966). Before evaporation, it is filtered through a four-layer gauze, then loaded into a vacuum device and stirred at a temperature of 60-70oC until the moisture content of the product does not exceed 50% and reaches a specific weight (Krebs, 1973). Evaporation is carried out with a slow boiling of bile (West Publishing, 1962). The yield of condensed bile is on average 10% of the weight of native bile (Weyant, 1965). Condensed bile, which is a thick syrupy liquid of dark brown or greenish color with a sharp specific, but not putrid smell, is poured into a barrel or cans and tightly capped (Zając, 1914).

The dependence of the density and viscosity of bile extracts on the evaporation time and moisture is determined experimentally (Weyant, 1971). The percentage of bile extract changes under thermal influence and the density is measured using a densimeter (Zelenyak, 2018).

RESULTS AND DISCUSSION

Denote by $x_1 = t, x_2 = W, g(x_1, x_2) = \rho(\mathrm{t}, \mathrm{w})$

Under such assumptions, it is necessary to construct a piecewise bicubic interpolation of the function $g(x_1, x_2)$ specified in points $D_\hbar = \{T_0 \le x_1 \le T_N \mu_0 \le x_2 \le \mu_N\}$, according to. This process consists of building a function $g(x_1, x_2)$ satisfying the conditions:

1) $g(x_1, x_2) \in C^2(D)$;

2) в each cell of the grid $g(x_1, x_2)$ is a bicubic polynomial of the form

$$g(x_1, x_2) = g_{k,l}(x_1, x_2) = \sum_{i,j=0}^{3} a_{i,j}^{k,l} (x_{1k} - x_1)^i \cdot (x_{2l} - x_2)^j \quad ; \qquad (4)$$

3) on the grid D_h $g(x_1, x_2)$ accepts the specified values

$g(x_{1k}, x_{2l}) = \rho_{kl}^{\varepsilon}, k = 0,1,\ldots,n_1;\ l = 0,1,\ldots,n_2;$

4) function $g(x_1, x_2)$ satisfy the boundary conditions $\left.\frac{\partial^2 g}{\partial \nu^2}\right|_{S_1} = 0$

(here ν - external normal to the border S_1 areas D)

Let's first consider one-dimensional cubic spline interpolation problems on grid lines $x_2 = x_{2,j}\ (j = 0,1,\ldots,n_2)$.

By $x_{1,i-1} \le x_1 \le x_{1,i}$ we can record

$$g_{x_1 x_1}(x_1, x_{2,j}) = m_{i-1} \frac{x_{1,i} - x_1}{h_i} + m_i \frac{x_1 - x_{1,i-1}}{h_i},\ i = 1,2,\ldots,n_1 - 1$$

$$\frac{h_i}{6} m_{i-1} + \frac{h_i + h_{i+1}}{3} m_i + \frac{h_{i+1}}{6} m_{i+1} = \frac{\mu(x_{1,i+1}, x_{2,j}) - \mu(x_{1,i}, x_{2,j})}{h_{i+1}} - \frac{\mu(x_{1,i}, x_{2,j}) - \mu(x_{1,i-1}, x_{2,j})}{h_i},$$

$$i = 1,2,\ldots,n_1 - 1$$

Let's add these equations from the conditions $\left.\frac{\partial^2 g}{\partial \nu^2}\right|_{S_1} = 0$ equalities $m_0 = m_{n_1} = 0$. To do this, we decide $(n_2 + 1)$ linear algebraic systems of the type

$$A_1 m = H_1 \mu \qquad (5)$$

$$A_1 = \begin{Vmatrix} \frac{h_1+h_2}{3} & \frac{h_2}{6} & 0 & \dots & 0 & 0 \\ \frac{h_2}{6} & \frac{h_2+h_3}{3} & \frac{h_3}{6} & \dots & 0 & 0 \\ 0 & \frac{h_3}{6} & \frac{h_3+h_4}{3} & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & \frac{h_{n_1-1}}{6} & \frac{h_{n_1}+h_{n_1-1}}{3} \end{Vmatrix} \quad (6)$$

Vectors m and μ and a rectangular matrix H_1 such a

$$m = \begin{Vmatrix} m_1 \\ m_2 \\ \dots \\ m_{n_1-1} \end{Vmatrix}, \quad \mu = \begin{Vmatrix} \mu_{0,j} \\ \mu_{1,j} \\ \mu_{2,j} \\ \dots \\ \mu_{n_1,j} \end{Vmatrix},$$

$$H_1 = \begin{Vmatrix} \frac{1}{h_1} & \left(-\frac{1}{h_1}-\frac{1}{h_2}\right) & \frac{1}{h_2} & \dots & 0 & 0 \\ 0 & \frac{1}{h_2} & \left(-\frac{1}{h_2}-\frac{1}{h_3}\right) & \dots & 0 & 0 \\ 0 & 0 & \frac{1}{h_3} & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & \left(-\frac{1}{h_{n_1-1}}-\frac{1}{h_{n_1}}\right) & -\frac{1}{h_{n_1}} \end{Vmatrix} \quad (7)$$

We solve the system of linear equations (5) using the run-through method and find the values of the function as a result $g_{x_1x_1}(x_1,x_2)$ in the grid nodes D_h.

Then we solve the same problem n_1+1 problems of one-dimensional spline interpolation on lines $x_1 = x_{1,i}(i=0,1,\dots,n_1)$ and find the value of the function $g_{x_2x_2}(x_1,x_2)$ на D_h.

By $x_{2,j-1} \le x_2 \le x_{2,j}$ we can record

$$g_{x_2x_2}(x_{1,i},x_2) = m_{j-1}\frac{x_{2,j}-x_2}{\tau_j} + m_j\frac{x_2-x_{2,j-1}}{\tau_j},\ j=1,2,\dots,n_2-1 \quad (8)$$

From the continuity condition $g_{x_2}(x_{1,i},x_2)$ in points $x_{21},x_{22},x_{23},\dots,x_{2,n_2-1}$ receive n_2-1 equation

$$\frac{\tau_j}{6}m_{j-1}+\frac{\tau_j+\tau_{j+1}}{3}m_j+\frac{\tau_{j+1}}{6}m_{j+1}=\frac{\mu(x_{1,i},x_{2,j+1})-\mu(x_{1,i},x_{2,j})}{\tau_{j+1}}-$$
$$-\frac{\mu(x_{1,i},x_{2,j})-\mu(x_{1,i},x_{2,j-1})}{\tau_j},\ j=1,2,\ldots,n_2-1 \qquad (9)$$

We Supplement these equations with equalities $m_0=m_{n_2}=0$. These equations in matrix form have the following form $A_2 m=H_2\mu$ (10)

$$A_2=\begin{Vmatrix} \frac{\tau_1+\tau_2}{3} & \frac{\tau_2}{6} & 0 & \ldots & 0 & 0 \\ \frac{\tau_2}{6} & \frac{\tau_2+\tau_3}{3} & \frac{\tau_3}{6} & \ldots & 0 & 0 \\ 0 & \frac{\tau_3}{6} & \frac{\tau_3+\tau_4}{3} & \ldots & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & 0 & \ldots & \frac{\tau_{n_2-1}}{6} & \frac{\tau_{n_2}+\tau_{n_2-1}}{3} \end{Vmatrix}$$

where (11)

Vectors m and μ, rectangular matrix H_2 such a

$$m=\begin{Vmatrix} m_1 \\ m_2 \\ \ldots \\ m_{n_2-2} \\ m_{n_2-1} \end{Vmatrix},\quad \mu=\begin{Vmatrix} \mu_{i,0} \\ \mu_{i,1} \\ \mu_{i,2} \\ \ldots \\ \mu_{i,n_2} \end{Vmatrix},$$

$$H_2=\begin{Vmatrix} \frac{1}{\tau_1} & \left(-\frac{1}{\tau_1}-\frac{1}{\tau_2}\right) & \frac{1}{\tau_2} & \ldots & 0 & 0 \\ 0 & \frac{1}{\tau_2} & \left(-\frac{1}{\tau_2}-\frac{1}{\tau_3}\right) & \ldots & 0 & 0 \\ 0 & 0 & \frac{1}{\tau_3} & \ldots & 0 & 0 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ 0 & 0 & 0 & \ldots & \left(-\frac{1}{\tau_{n_2-1}}-\frac{1}{\tau_{n_2}}\right) & -\frac{1}{\tau_{n_2}} \end{Vmatrix} \qquad (12)$$

Function value $g(x_1,x_2)$ in points $(x_{1,i},x_2)$, $(x_{1,i-1},x_2)$ is based on the formulas

$$g(x_{1,i-1},x_2)=N_{i-1,j-1}\frac{(x_{2,j}-x_2)^3}{6\tau_j}+N_{i-1,j}\frac{(x_2-x_{2,j-1})^3}{6\tau_j}+$$
$$+\left(\mu_{i-1,j-1}-\frac{N_{i-1,j-1}\tau_j^{\ 2}}{6}\right)\frac{x_{2,j}-x_2}{\tau_j}+\left(\mu_{i-1,j}-\frac{N_{i-1,j}\tau_j^{\ 2}}{6}\right)\frac{x_2-x_{2,j-1}}{\tau_j}, \qquad (13)$$

$$g(x_{1,i},x_2)=N_{i,j-1}\frac{\left(x_{2,j}-x_2\right)^3}{6\tau_j}+N_{i,j}\frac{\left(x_2-x_{2,j-1}\right)^3}{6\tau_j}+$$
$$+\left(\mu_{i,j-1}-\frac{N_{i,j-1}\tau_j^{\ 2}}{6}\right)\frac{x_{2,j}-x_2}{\tau_j}+\left(\mu_{i,j}-\frac{N_{i,j}\tau_j^{\ 2}}{6}\right)\frac{x_2-x_{2,j-1}}{\tau_j} \qquad (14)$$

Here and further $N_{i,j}=g_{x_2x_2}(x_{1,i},x_{2,j}),\ M_{i,j}=g_{x_1x_1}(x_{1,i},x_{2,j}),\ h_i=x_{1,i}-x_{1,i-1},\ \tau_j=x_{2,j}-x_{2,j-1}$.

Next, if the known values are $g_{x_1x_1}(x_{1,i-1},x_2)$ и $g_{x_1x_1}(x_{1,i},x_2)$, then you can find the values $g(x_1,x_2)$.

Note that the function $g_{x_1x_1}(x_1,x_2)$ is piecewise cubic by x_2. Solve n_2+1 one-dimensional problems on lines $x_2=x_{2,j}$ for the function $g_{x_1x_1}(x_1,x_2)$ the grid values of which are already known.

$$g_{x_1x_1x_2x_2}=m_{j-1}\frac{x_{2,j}-x_2}{\tau_j}+m_j\frac{x_2-x_{2,j-1}}{\tau_j}, \qquad (15)$$

$$\frac{\tau_j}{6}m_{j-1}+\frac{\tau_j+\tau_{j+1}}{3}m_j+\frac{\tau_{j+1}}{6}m_{j+1}=\frac{g_{x_1x_1}(x_1,x_{2,j+1})-g_{x_1x_1}(x_1,x_{2,j})}{\tau_{j+1}}-$$
$$-\frac{g_{x_1x_1}(x_1,x_{2,j})-g_{x_1x_1}(x_1,x_{2,j-1})}{\tau_j},\ j=1,2,\ldots,n_2-1$$

As a result, we find on D_h function $g_{x_1x_1x_2x_2}(x_{1,i},x_{2,j})$. Denote $K_{i,j}=g_{x_1x_1x_2x_2}(x_{1,i},x_{2,j})$

Then

$$g_{x_1x_1}(x_{1,i-1},x_2)=K_{i-1,j-1}\frac{\left(x_{2,j}-x_2\right)^3}{6\tau_j}+K_{i-1,j}\frac{\left(x_2-x_{2,j-1}\right)^3}{6\tau_j}+$$
$$+\left(M_{i-1,j-1}-\frac{K_{i-1,j-1}\tau_j^{\ 2}}{6}\right)\frac{x_{2,j}-x_2}{\tau_j}+\left(M_{i-1,j}-\frac{K_{i-1,j}\tau_j^{\ 2}}{6}\right)\frac{x_2-x_{2,j-1}}{\tau_j}, \qquad (16)$$

$$g_{x_1x_1}(x_{1,i},x_2)=K_{i,j-1}\frac{\left(x_{2,j}-x_2\right)^3}{6\tau_j}+K_{i,j}\frac{\left(x_2-x_{2,j-1}\right)^3}{6\tau_j}+$$
$$+\left(M_{i,j}-\frac{K_{i,j-1}\tau_j^{\ 2}}{6}\right)\frac{x_{2,j}-x_2}{\tau_j}+\left(M_{i,j}-\frac{K_{i,j}\tau_j^{\ 2}}{6}\right)\frac{x_2-x_{2,j-1}}{\tau_j} \qquad (17)$$

Then we finally find the value $g(x_1,x_2)$:

$$g(x_1,x_2)=g_{x_1x_1}(x_{1,i-1},x_2)\frac{\left(x_{1,i}-x_1\right)^3}{6h_i}+g_{x_1x_1}(x_{1,i},x_2)\frac{\left(x_1-x_{1,i-1}\right)^3}{6h_i}+$$
$$+\left(g(x_{1,i-1},x_2)-\frac{g_{x_1x_1}(x_{1,i-1},x_2)h_i^2}{6}\right)\frac{x_{1,i}-x_1}{h_i}+$$
$$+\left(g(x_{1,i},x_2)-\frac{g_{x_1x_1}(x_{1,i},x_2)h_i^2}{6}\right)\frac{x_1-x_{1,i-1}}{h_i} \quad (18)$$

CONCLUSION

The formula (18) is very convenient for finding the value of the function p with a certain accuracy for any values of temperature T and viscosity μ, according to the notations

$$x_1=t, x_2=W, g(x_1,x_2)=\rho(\mathrm{t},\mathrm{w})$$

A computer program was created to calculate the value of the density function in the considered range of changes in viscosity and temperature.

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