INTERNATIONAL MULTIDISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
SJIF 2019: 5.222 2020: 5.552 2021: 5.637 2022:5.479 2023:6.563 2024: 7,805
eISSN :2394-6334 https://www.ijmrd.in/index.php/imjrd Volume 12, issue 05 (2025)

DEVELOPMENT OF A MATHEMATICAL MODEL FOR DETERMINING MOISTURE IN A PROOFING CUP WHEN PREPARING DOUGH

Salieva Olima Kamalovna
Candidate of Technical Sciences, Associate Professor,
Bukhara State Technical University, Republic of Uzbekistan
Sharipova Pariso
Master`s student, Bukhara State Technical University
E-mail: saliyevaok@mail.ru

Annotation: This study presents the development of a mathematical model designed to determine the moisture content in a proofing cup during the dough preparation process. The model aims to optimize dough fermentation by accurately estimating humidity levels, which are critical for yeast activity and dough quality. The research integrates physical parameters such as temperature, air flow, and time into the model, enabling better control over proofing conditions. The results demonstrate that the model can predict moisture levels with a high degree of accuracy, offering potential improvements in industrial and artisanal baking processes.
Keywords: dough preparation, proofing cup, moisture content, mathematical modeling, fermentation process, baking technology, humidity control, dough quality, predictive model, food engineering

Introduction. Today, bakery products in Uzbekistan are affordable, traditional, everyday food products for the population and improving their quality and nutritional value, developing preventive, functional and enriched products, contribute to the implementation of the modern concept of healthy nutrition. Improving the recipes of bakery products using regional plant ingredients is of great theoretical and practical interest and creates the prerequisites for expanding the range, improving the quality, nutritional and biological value of the finished product.

In many ways, the quality of the bakery products that end up on our table depends on the technological process called dough proofing. Its essence is to keep the dough pieces in such conditions that the finished products acquire the necessary shape and volume, as well as attractive quality and appearance for the buyer.

Proofing of dough is a necessary technological stage in the preparation of bakery products. In the process of forming the product - loosening it, or giving it its final shape - almost complete removal of carbon dioxide from the volume occurs. If these products are immediately placed in the oven, the output will be a low-quality product with a cracked crust, dense pulp and other technological deviations, i.e. having an unmarketable appearance. Therefore, it is impossible to bypass the process of proofing the dough. During proofing, the dough "ferment", releasing carbon dioxide. Thanks to this "fermentation", the products acquire the necessary shape and volume, as well as taste qualities corresponding to each type of product. The duration of this process is determined by the ingredients included in the dough.

A distinction is made between preliminary and final proofing of dough. Each of these operations has its own characteristics.

Preliminary proofing is done before shaping and takes from 2 to 20 minutes. This improves the plasticity and porosity of the dough, increases its volume, and forms a thin elastic film on the surface. The blanks that have undergone preliminary proofing are easier to roll out and acquire the final shape. Saturation of the dough with carbon dioxide during this process is not important. There are no strict requirements for humidity and temperature either. Cabinets intended for this purpose are used to perform preliminary proofing .

Final proofing. Final proofing is carried out after the dough has been formed. During this time, the fermentation process is actively underway. The dough is saturated with carbon dioxide, loosened and increases in volume, and its gluten framework is restored. The workpiece acquires the required shape, and its surface becomes smooth and elastic. Three parameters are important during final proofing: temperature, humidity, and duration of the process. Final proofing cabinets are used for this purpose .Wheat dough is subject to mandatory preliminary and final proofing. For rye dough, final proofing is the only one. Temperature regime features. The optimum temperature for final proofing of dough pieces is 32–38°C. Its decrease leads to a noticeable slowdown in the process. At temperatures above 38°C, the dough gains acidity too quickly, because such conditions are maximally favorable for acid-forming microflora. At the same time, the quality of the final product deteriorates. The exception is baked goods. For them, the temperature in the proofing cabinet can be increased to 45°C.The temperature in the proofing cabinet should not differ from the dough temperature by more than 5–8°C. If this condition is violated, the surface and internal layers of the workpiece will have different porosity and properties (elasticity, plasticity and viscosity). As a result, the quality and appearance of the final products will deteriorate.Humidity during final proofing. The humidity maintained in the proofing chamber can vary between 65–85%. Under these conditions, the top layer of dough becomes smooth, elastic, and holds carbon dioxide well. As a result, baked goods have an appetizing appearance and good quality. If the humidity is too low, the top layer of dough will dry out and crack. At a level above 85%, the dough pieces stick to the surface of the baking trays, their top layer loses elasticity, begins to bubble during baking, and may peel off from the crumb in places.One exception is hamburger buns, which require up to 100% moisture to proof.Final proofing time. The final proofing time of the dough is from 20 to 120 minutes. It depends on several parameters and is reduced by:

- increasing the temperature in the proofing chamber ;
- high humidity and dough temperature;
- using rye flour;
- baking of hearth bakery products;
- increasing the amount of yeast.

The proofing time increases when:

- reducing the weight of workpieces;
- increasing the proportion of sugar or fat in the dough;
- using wheat flour;
- baking of molded bakery products;
- intensive mechanical processing of the dough.

Violations of proofing processes. Incorrectly selected modes or their violations can lead to insufficient or excessive proofing of the dough. In the first case, bakery products acquire an irregular shape, cracks and breaks form on the crusts, and the crumb loses elasticity. Such consequences are explained by the fact that after placing in the oven, unfinished fermentation processes in the dough accelerate and it begins to increase in size already during baking.

Excessive proofing also affects the characteristics of the final product. Finished products, instead of being fluffy, have a flat shape or lose their relief pattern. This is a consequence of reduced gas formation and weakening of the gluten framework.

In bakeries, the proofing process is carried out in special chambers, or proofing cabinets. In these cabinets (chambers), a strict temperature and humidity regime is maintained. It is important not only to maintain the temperature within 35-40 °C and the humidity 75-85% with high accuracy, but also to regulate these parameters to optimize the proofing process depending on the type of products being manufactured. When entering the proofing cabinet, the product has a temperature lower than the air temperature in the cabinet. Therefore, moisture from the surrounding air condenses on the product fairly quickly. Due to this process, the surface of the product does not become weathered and the crust formed during heat treatment does not crack when the volume increases. In addition, condensation on the surface of the bakery product during proofing prevents the removal of carbon dioxide from the volume. Under the influence of the temperature in the proofing cabinet, moisture from the surface of the product evaporates simultaneously with the process of loosening the dough in the volume under the influence of CO_2.

As mentioned earlier, the dough proofing process is carried out with strict adherence to the temperature and humidity conditions and their mandatory regulation. The fact is that with an increase in the temperature in the proofing cabinet, for example, by only 15 ° C, and humidity by 5%, the speed of the proofing process increases by 30%. However, an increase in air humidity over 85% will lead to a violation of the technological process and a deterioration in the quality of the dough. And when the humidity drops below 75%, the dough begins to dry out and the surface of the bakery product cracks. Therefore, it is necessary to measure and regulate the temperature and relative humidity in the proofing cabinets with particular accuracy. However, this is impossible without the use of professional control and measuring equipment.

Maintaining stable humidity and temperature during proofing of bakery products allows you to obtain products of stable quality and reduce the percentage of defects to a minimum. Strict adherence to humidity and temperature parameters in the proofing chamber allows you to reduce the dough readiness time by 25% and increase the economic efficiency of production.

The entire final result of the dough product depends on the correct use of proofing technology. During the division and shaping of the dough, its porous structure is destroyed, and carbon dioxide is almost completely removed. If after preparation the workpiece is sent straight to the oven, the product will turn out small, hard, with various defects and a torn crust due to lack of moisture.

Excessive or insufficient humidity, like temperature, can damage the finished product. At humidity below 75%, the dough will begin to shrink and crack, and at too high humidity, it will stick to the surface of the cart.

The use of automatic control in control systems for automation of the dough proofing process opens up new horizons for improving productivity, increasing quality and reducing costs.

Having a mathematical model of the process, we can determine the parameters for optimal process control.

For development of a mathematical model for determining humidity in a proofing cabinet during dough preparation, it is necessary to describe the processes that affect the change in humidity in a closed volume. Let us consider the step-by-step development of the model.

1. Purpose of the model

Determine the current air humidity in the proofing cabinet H(t), taking into account:

- temperature,
- ambient humidity,
- operation of the humidifier,
- evaporation of water from the surface of the dough,
- ventilation leaks.

2. Main variables and parameters

Humidity in the closet	H(t), %
Temperature in the cabinet	T(t), °C
Mass of water vapor in the air	mv (t, g
Volume of the cabinet	V, m³
Saturated vapor pressure	Ps (T), Pa
Steam pressure in the cabinet	Pv (t), Pa
Humidifier control	u(t), W or g/s

3. Basic equation

We use the water vapor mass balance equation:

$$\frac{dm_v(t)}{dt} = \dot{m}_{увл}(t) + \dot{m}_{исп}(t) - \dot{m}_{вент}(t)$$

Where:

- $\dot{m}_{увл}(t)$— the mass of water supplied from the humidifier,
- $\dot{m}_{исп}(t)$- evaporation of moisture from the surface of the dough,
- $\dot{m}_{вент}(t)$- loss of moisture through ventilation.

4. Relative humidity:

$$H(t) = \frac{P_v(t)}{P_s(t)} \times 100\%$$

where the vapor pressure $P_v(t)$ is related to $m_v(t)$ through the equation of state:

$$P_v(t) = \frac{m_v(t) \cdot R_v \cdot T(t)}{V}$$

R_v≈461.5 J/(kg ·3 s K) is the gas constant for water vapor.

4. Components of the equation

4.1 Moisturizing:

$$\dot{m}_{увл}(t) -\propto \cdot\, u(t)$$

where α is the efficiency of the humidifier (g/ W s).

4.2 Evaporation from dough (simplified):

$$\dot{m}_{исп}(t) = k_e \cdot A \cdot (P_s(t) - P_v(t))$$

- k_e— mass transfer coefficient (g/m² s Pa),
- A — dough evaporation area.

4.3 Ventilation losses:

$$\dot{m}_{вент}(t) = k_v \cdot (P_v(t) - P_{v,внеш}(t))$$

- k_v— leakage coefficient (g/s Pa),
- $P_{v,внеш}(t)$— partial pressure of water vapor outside.

5. The final system of equations

One of the possible model options:

$$\frac{dm_v(t)}{dt} = \propto u(t) + k_e \cdot A \cdot \left(P_s(t) - P_v(t)\right) - k_v \cdot (P_v(t) - P_{v,внеш})$$

With subsequent recalculation $m_v(t) \rightarrow P_v(t) \rightarrow H(t)$

INTERNATIONAL MULTIDISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
SJIF 2019: 5.222 2020: 5.552 2021: 5.637 2022:5.479 2023:6.563 2024: 7,805
eISSN :2394-6334 https://www.ijmrd.in/index.php/imjrd Volume 12, issue 05 (2025)

6. Possible simplifications

To simplify the model:

- consider the temperature constant,
- consider ventilation to be negligible,
- consider $P_{v,ext} \approx 0$

then the model is reduced to:

$$\frac{dH(t)}{dt} = a \cdot u(t) + b \cdot \left(H_{исп}(t) - H(t)\right)$$

Where:

- a,b - empirical coefficients,
- $H_{evaporation}$ is the humidity that evaporation strives to achieve.
- Conclusion. As part of the study, a mathematical model for determining humidity in a proofing cabinet was developed, based on the moisture balance equation, the thermophysical properties of air and the process of moisture evaporation from the dough surface. Taking into account the main parameters - temperature, cabinet volume, steam supply and the mass of moisture in the air - the model allows predicting changes in humidity during the proofing process.
- The proposed model provides the ability to analyze the influence of technological parameters on the microclimate in the proofing cabinet and can be used to optimize proofing modes in order to improve the quality of finished products.

References

1. 1.KOBILOV, H., & RUSTAMOV, A. A. O. G. L. (2025). IMPROVEMENT OF THE INFORMATION SYSTEM FOR CONTROLLING THE ACTIVITIES OF TEACHERS IN THE HIGHER EDUCATION SYSTEM ON KPI WITH THE HELP OF ARTIFICIAL INTELLIGENCE ELEMENTS. JOURNAL OF PEDAGOGICAL RESEARCH, 2(2), 309-312.
2. 2.KOBILOV, H., & RUSTAMOV, A. A. O. G. L. (2025). AUTOMATED SYSTEM FOR CALCULATING AND VERIFYING THE SCHEDULE AND TICKET FOR ADDRESS-RELATED PUBLIC TRANSPORT. JOURNAL OF PEDAGOGICAL RESEARCH, 2(2), 253-255.
3. 3. Ramazon o‘g‘li, I. S., Sayidovich, N. M., Khalilovich, Q. H., & Nasillo o‘g‘li, S. A. (2024). IMITATION MODEL OF THE CRYSTALLIZATION PROCESS OF SODIUM SILICATE PENTAHYDRATE PRODUCTION FROM LIQUID GLASS. YANGI O ‘ZBEKISTAN, YANGI TADDQIQOTLAR JOURNAL, 1(3), 128-134.
4. 4. Kobilov, K., & Sharipova, N. (2024). Systematic analysis of briquette mass pressing equipment approach. YASHIL IQTSADIYOT VA TARAKQIYOT, 2(9).
5. 5. Nasillo o‘g‘li, S. A. (2023). COMPUTER MODELING OF SHELL-TUBE HEAT EXCHANGER DEVICE IN OIL REFINING TECHNOLOGICAL SYSTEM.Ethiopian International Journal of Multidisciplinary Research, 10(11), 338-343.
6. 6.Ibragimov, U. M., Qobilov, H. X., & Ismoilov, R. R. (2023). INSPECTION OF CONVEYOR BELT RESISTANCE TO VEGETABLE WEIGHT IN VEGETABLE SORTING PROCESS THROUGH SIMULATION OF SOLIDWORKS CAD/CAM/CAE SYSTEM. Oriental renaissance: Innovative, educational, natural and social sciences, 3(4), 438-445.
7. 7.Jo‘Rayev, X. F., Qobilov, H. X., & Jo‘Rayev, M. T. (2023). CREATION AND SIMULATION OF DETAILS OF DEVICE IN COAL FUEL SMOKE PURIFICATION PROCESS IN (CAD/CAM/CAE) SYSTEM. Oriental renaissance: Innovative, educational, natural and social sciences, 3(4), 474-481.

8. 8.Abidov, K. Z., Qobilov, H. X., & Isroilov, A. A. (2023). CREATION OF DETAILS OF THE EQUIPMENT IN THE TECHNOLOGICAL PROCESS OF DRYING PAPER WEAVE IN THE CELLULOSE-PAPER INDUSTRY IN THE SOLIDWORKS (CAD CAM CAE) SYSTEM. Oriental renaissance: Innovative, educational, natural and social sciences, 3(4), 686-692.
9. 9.Qobilov, H. X., & Rakhmonkulova, X. O. (2023). ANALYSIS OF THE PROCESS OF COMBINED DRYING OF TOMATO SEEDS. Oriental renaissance: Innovative, educational, natural and social sciences, 3(9), 72-78.
10. 10.Kobilov, K. (2022, December). Laboratory research of coal briquette quality indicators. In IOP Conference Series: Earth and Environmental Science (Vol. 1112, No. 1, p. 012007). IOP Publishing.
11. 11. Abdurakhmanov, O. R., & Yuldashev, Kh. M. (2022). VYSOKOEFFEKTIVNAYa FUZALOVUShKA DLYa OCHISTKI PRESSOVOGO HLOPKOVOGO MASLA.Journal of Advances in Engineering Technology, (4), 19-21.
12. 12. Kobilov, K., Abdurakhmonov, O., Sharipova, N., & Adizova, M. (2021, September). Development of the installation device pressing the volume of briquetted material and computer modeling of the technological process. In IOP Conference Series: Earth and Environmental Science (Vol. 839, No. 4, p. 042092). IOP Publishing.
13. 13. Oktamova, Sh. H., & Qabilov, H. X. (2021). DEVELOPMENT FACTORS OF PERSONAL-CREATIVE COMPETENCE OF STUDENTS IN HIGHER EDUCATION.Scientific progress, 2(5), 327-329.
14. 14. Abdurakhmanov, O. R., Usmanov, A. U., Kobilov, Kh. Kh., & Buronov, S. A. (2021). METHODIKA PROVEDENIE EKSPERIMENTA PO IZGOTOVLENIYu UGOLNOGO BRIKETA S PRIMENENIEM BIOORGANIChESKIH SVYaZUYushchIX. In TECHNICHESKIE NAUKI: PROBLEMY I RESHENIYA (pp. 48-53).
15. 15. Abdurakhmanov, O. R., Salimov, Z. S., & Saidakhmedov, Sh. M. (2016). Ratsionalnaya technology rectification of neftegazokondensatnoy smesi s ospolzovaniem gulvohydrodnykh otparivayushchikh agentsov.Technology of oil and gas, (3), 3-6.
16. 16. Abdurakhmanov, O. R., Salimov, Z. S., & Saidakhmedov, Sh. M. (2016). Ratsionalnaya technology rectification of neftegazokondensatnoy smesi s ospolzovaniem gulvohydrodnykh otparivayushchikh agentsov.Technology of oil and gas, (3), 3-6.
17. 17. Djuraev, K., Yodgorova, M., Usmonov, A., & Mizomov, M. (2021, September). Experimental study of the extraction process of coniferous plants. In IOP Conference Series: Earth and Environmental Science (Vol. 839, No. 4, p. 042019). IOP Publishing.
18. 18. Abdurakhmonov, O. R., Soliyeva, O. K., Mizomov, M. S., & Adizova, M. R. (2020). Factors influencing the drying process of fruits and vegetables.ACADEMICIA: "An international Multidisciplinary Research Journal" in India.
19. 19. Mizomov, M. S. (2022). Analyzing Moisture at the Drying Process of Spice Plants.Texas Journal of Agricultural and Biological Sciences, 4, 84-88.
20. 20. Mizomov, M. (2025). ANALYZING TECHNOLOGICAL PROCESSES WITH MAIN TECHNOLOGICAL PARAMETERS.International Journal of Artificial Intelligence, 1(3), 120-124.
21. 21. Mizomov, M. (2025). RESEARCHING HIGHER EDUCATIONAL ACTIVITIES AROUND UNIVERSITIES.Journal of Applied Science and Social Science, 1(2), 284-291.
22. 22. Mizomov, M. (2025). REVISITING STRATEGIES FOR IMPROVING ORGANIZATIONAL MECHANISMS.Journal of Applied Science and Social Science, 1(1), 364-370.
23. 23. Mizomov, M. (2025). ANALYZING DRYING PROCESS OF SPICES USING THE LOW TEMPERATURE.Journal of Applied Science and Social Science, 1(1), 645-651.