TECHNOLOGICAL EFFICIENCY OF COMBINED DRYING OF DIFFERENT QUINCE (*CYDONIA OBLONGA* MILL.) CULTIVARS

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Abstract. The efficiency of fruit drying is largely determined by the interaction between the technological parameters of the drying process and the biological and physicochemical characteristics of the raw material. Quince (Cydonia oblonga Mill.) is considered a promising raw material for dried fruit production due to its relatively high content of dry matter, sugars, organic acids, pectin substances, and other valuable components. However, the dense tissue structure of quince may restrict moisture migration and prolong the drying process, resulting in increased energy consumption. The present study aimed to evaluate the technological efficiency of combined convective–infrared drying of seven quince cultivars: Samarqand yirik mevasi, Toshkent yumaloq behi, Andijon behi, Qoʻqon behi, Desertnaya, Krupnoplodnaya, and Maslyanka pozdnyaya. The experiments were conducted during 2023–2025 under laboratory and semi-industrial conditions. Drying performance was evaluated according to drying duration, final moisture content, dried product yield, reduction in drying time, and reduction in energy consumption.

The results demonstrated cultivar-dependent differences in drying performance. The most favourable technological characteristics were observed for Desertnaya and Krupnoplodnaya. Under the combined drying conditions, the reduction in drying duration reached 18–22%, while dried product yield ranged from 17.5 to 19.8%. Energy consumption was reduced by approximately 12–15% compared with the conventional drying approach. Samarqand yirik mevasi and Qoʻqon behi also demonstrated favourable technological properties, particularly in terms of dried product yield. The findings indicate that cultivar selection is an important factor in improving the technological efficiency of quince drying. The integration of appropriate cultivar characteristics with combined convective–infrared drying can contribute to shorter processing times, lower energy requirements, and increased dried product yield.

Keywords: quince, Cydonia oblonga Mill., cultivar, combined drying, convective drying, infrared drying, drying efficiency, product yield, energy consumption.

Introduction.

Drying is one of the most widely applied methods for extending the storage life of fruit products. Reduction of moisture content decreases water activity, suppresses microbial development, slows biochemical deterioration, and allows processed products to be stored for longer periods. At the same time, drying reduces product mass and volume, thereby facilitating packaging, transportation, and storage.

Quince (Cydonia oblonga Mill.) is of particular interest for drying because of its valuable biochemical composition. Quince fruits contain considerable amounts of dry matter, sugars, organic acids, pectin substances, vitamins, and other biologically active compounds. These characteristics make quince a promising raw material for the production of dried and semi-processed fruit products.

Nevertheless, the technological properties of quince create certain difficulties during drying. Its relatively firm and dense tissue structure may limit internal moisture diffusion. As a result, conventional convective drying may require prolonged exposure to elevated temperatures, which increases energy requirements and may negatively affect the quality of the final product.

The application of combined drying technologies represents one approach to addressing these limitations. In particular, the integration of convective hot-air drying with infrared energy can intensify heat and mass transfer. Convective airflow facilitates the removal of moisture from the product surface, while infrared radiation provides additional thermal energy to the fruit tissue. The interaction of these mechanisms can shorten drying duration and improve the overall energy efficiency of the process.

However, technological efficiency is determined not only by the drying method but also by cultivar-specific characteristics. Differences in dry matter content, initial moisture, tissue structure, sugar concentration, and other physicochemical properties may substantially influence drying kinetics and dried product yield. Consequently, the same drying conditions may produce different technological results when applied to different quince cultivars.

The selection of cultivars with favourable drying characteristics is therefore important for improving the efficiency of industrial quince processing. A comparative evaluation of different cultivars under similar drying conditions can provide a basis for identifying raw materials that combine high dried product yield with reduced processing time and energy requirements.

The **objective of this study** was to comparatively evaluate the technological efficiency of combined convective–infrared drying of different quince (Cydonia oblonga Mill.) cultivars based on drying duration, final moisture content, dried product yield, and energy efficiency, and to identify the cultivars most suitable for dried quince production.

Materials and Methods

The study was conducted during **2023–2025** under laboratory and semi-industrial conditions. Seven quince (Cydonia oblonga Mill.) cultivars were used as experimental materials: **Samarqand yirik mevasi, Toshkent yumaloq behi,**

Andijon behi, Qo‘qon behi, Desertnaya, Krupnoplodnaya, and Maslyanka pozdnyaya.

Healthy fruits without visible mechanical damage or disease symptoms were selected for the experiments. Before drying, the fruits were washed and prepared according to the experimental procedure.

The quince samples were dried using a combined method integrating **convective hot-air and infrared energy**. The technological performance of the drying process was evaluated using the following indicators: drying duration (h), final moisture content (%), dried product yield (%), reduction in drying time (%), and reduction in energy consumption (%).

An effective drying regime was established at a temperature of **65 °C** and an air velocity of **1.5 m/s**. The experiments were carried out in 3–4 replications.

The dried product yield was determined as the ratio of the mass of the dried product to the initial mass of fresh quince fruit and expressed as a percentage:

$$\mathbf{Y = (M_2 / M_1) \times 100}$$

where: **Y** – dried product yield, %; $\mathbf{M_1}$ – initial mass of fresh quince, kg; $\mathbf{M_2}$ – mass of the dried product, kg.

The technological efficiency of combined drying was evaluated by comparing the drying responses of the investigated cultivars and determining the reduction in processing time and energy consumption.

Results and Discussion

The results showed that the efficiency of combined convective–infrared drying differed among the investigated quince cultivars. Cultivar characteristics influenced drying duration, final moisture content, dried product yield, and the overall efficiency of the drying process.

The technological parameters obtained for the seven cultivars are presented in Table 1.

Table 1. Technological performance of combined drying of different quince cultivars (2023–2025)

Cultivar	**Drying time, h**	**Final moisture content, %**	**Dried product yield, %**	**Reduction in drying time, %**	**Reduction in energy consumption, %**
Samarqand yirik mevasi	10.2	12.5	19.3	19.4	13.8
Toshkent yumaloq behi	10.8	12.8	17.6	17.2	11.9
Andijon behi	10.6	12.9	17.9	17.8	12.2
Qo‘qon behi	10.1	12.4	19.1	20.0	14.1
Desertnaya	**9.8**	**12.2**	**19.8**	**22.0**	**15.0**
Krupnoplodnaya	**9.9**	**12.3**	**19.5**	**21.3**	**14.7**

Maslyanka pozdnyaya	10.7	12.7	18.2	18.1	12.6

The results presented in Table 1 demonstrate that Desertnaya exhibited the highest technological efficiency among the investigated cultivars. The drying process was completed within 9.8 h, while the final moisture content was 12.2%. The dried product yield reached 19.8%, which was the highest value among the seven cultivars.

For Desertnaya, combined drying reduced the processing time by 22.0% and energy consumption by 15.0%. These results indicate that the physicochemical and structural characteristics of this cultivar were particularly favourable for moisture removal under combined convective–infrared drying conditions.

Similar results were obtained for Krupnoplodnaya. Its drying duration was 9.9 h, with a final moisture content of 12.3%. The dried product yield reached 19.5%, while drying time and energy consumption were reduced by 21.3 and 14.7%, respectively.

The results obtained for Samarqand yirik mevasi and Qoʻqon behi were also technologically favourable. The dried product yield reached 19.3% for Samarqand yirik mevasi and 19.1% for Qoʻqon behi. In Qoʻqon behi, the reduction in drying duration reached 20.0%, while energy consumption decreased by 14.1%.

In comparison, Toshkent yumaloq behi showed the longest drying duration of 10.8 h and the lowest dried product yield of 17.6%. Its reductions in drying time and energy consumption were 17.2 and 11.9%, respectively. Andijon behi showed similar characteristics, with a drying duration of 10.6 h and a product yield of 17.9%.

Maslyanka pozdnyaya occupied an intermediate position among the studied cultivars. The drying duration was 10.7 h, while the dried product yield reached 18.2%. Combined drying reduced processing time by 18.1% and energy consumption by 12.6%.

The differences in drying behaviour can be associated with cultivar-specific characteristics, particularly initial dry matter content and fruit tissue structure. Cultivars with relatively high dry matter content generally produced higher yields of dried product.

To illustrate this relationship, the initial dry matter content and dried product yield of the investigated cultivars were compared (Table 2).

Table 2. Relationship between initial dry matter content and dried product yield of quince cultivars

Cultivar	Initial dry matter, %	Dried product yield, %
Samarqand yirik mevasi	18.1	19.3
Toshkent yumaloq behi	16.1	17.6
Andijon behi	16.7	17.9
Qoʻqon behi	17.8	19.1
Desertnaya	**18.8**	**19.8**

Krupnoplodnaya	18.3	19.5
Maslyanka pozdnyaya	17.4	18.2

The comparison indicates a general tendency for cultivars with higher initial dry matter content to provide a greater yield of dried product. **Desertnaya**, with an initial dry matter content of 18.8%, produced the highest dried product yield of 19.8%. Krupnoplodnaya, containing 18.3% dry matter, provided a yield of 19.5%.

In contrast, Toshkent yumaloq behi had the lowest initial dry matter content (16.1%) and produced the lowest dried product yield (17.6%). This tendency indicates that the biochemical composition of the raw material should be considered when selecting quince cultivars for drying.

However, dry matter content alone cannot fully explain drying efficiency. Moisture migration is also influenced by tissue density, cellular structure, fruit composition, slice geometry, and heat and mass transfer conditions. Therefore, technological suitability should be assessed using a combination of raw material and processing indicators.

The results obtained in this study demonstrate the advantage of combining convective and infrared drying mechanisms. Convective airflow promotes the removal of evaporated moisture from the product surface, whereas infrared energy contributes to more intensive heating of the fruit tissue. Their combined action can accelerate moisture transfer and consequently shorten the drying cycle.

From a practical perspective, the reduction in drying time is particularly important because it may increase equipment productivity and reduce energy requirements per processing cycle. In the most responsive cultivars, combined drying reduced the processing duration by approximately 18–22%, while energy consumption decreased by up to 12–15%.

Based on the overall technological assessment, Desertnaya and Krupnoplodnaya demonstrated the greatest potential for efficient combined drying. At the same time, Samarqand yirik mevasi and Qoʻqon behi also showed favourable product yields and can be considered promising raw materials for dried quince production.

Conclusion

The results of the study demonstrated that the technological efficiency of combined convective–infrared drying of quince (Cydonia oblonga Mill.) depends considerably on cultivar characteristics.

Among the seven cultivars investigated, Desertnaya and Krupnoplodnaya showed the most favourable technological performance. Their drying duration was 9.8–9.9 h, while the final moisture content was maintained within the range of 12.2–12.3%. The dried product yield reached 19.5–19.8%.

The combined drying method reduced drying duration by 21.3–22.0% in these cultivars, while energy consumption decreased by 14.7–15.0%. These results indicate that the integration of convective and infrared energy can intensify moisture removal and improve the overall efficiency of quince drying.

Samarqand yirik mevasi and Qoʻqon behi also demonstrated favourable technological characteristics, with dried product yields of 19.3 and 19.1%, respectively. Therefore, these cultivars may also be considered promising raw materials for dried quince production.

A comparison of the initial composition and technological characteristics showed a general tendency for cultivars with higher dry matter content to provide higher dried product yields. However, drying performance is also influenced by tissue structure and heat and mass transfer characteristics. Consequently, cultivar selection should be considered an integral component of the technological design of quince drying.

Overall, Desertnaya and Krupnoplodnaya can be recommended as particularly promising cultivars for energy-efficient combined drying, while Samarqand yirik mevasi and Qoʻqon behi also have considerable potential for the production of dried quince products.

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