INFLUENCE OF PRETREATMENT TECHNIQUES ON DRYING PERFORMANCE AND QUALITY CHARACTERISTICS OF QUINCE (CYDONIA OBLONGA MILL.)

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Abstract. This study investigated the influence of different pretreatment techniques on drying performance and the quality characteristics of quince (Cydonia oblonga Mill.) fruit. Seven quince cultivars—Samarqand yirik mevasi, Toshkent yumaloq behi, Andijon behi, Qoqon behi, Dessertnaya, Krupnoplodnaya, and Maslyanka Pozdnyaya—were evaluated in terms of their biochemical and technological characteristics and their response to pre-drying treatments.

The pretreatment procedure involved slicing the fruits into 5–7 mm thick pieces, blanching at 85–90 °C for 2–3 min, and applying an antioxidant treatment with a 0.3% ascorbic acid solution. The effects of the treatments on enzymatic browning, natural colour preservation, vitamin C retention, drying duration, final moisture content, dried product yield, and organoleptic properties were evaluated.

The results showed that the combined pretreatment effectively reduced undesirable changes occurring in quince tissues before and during drying. Enzymatic browning was reduced by 42–48%, while preservation of the natural colour improved by 40–45%. Vitamin C retention reached 85–88%. Samarqand yirik mevasi and Qoqon behi showed particularly favourable responses to the applied pretreatment, demonstrating high colour stability and vitamin C retention.

The application of combined convective and infrared drying further improved technological performance. Dessertnaya and Krupnoplodnaya showed the highest drying efficiency, with drying duration reduced by 18–22% and dried product yield reaching 17.5–19.8%. The combined drying technology also reduced energy consumption by 12–15%. The findings indicate that integrating cultivar selection, appropriate pretreatment, and an efficient drying regime can improve the technological efficiency of quince processing while maintaining the quality characteristics of the dried product.

Keywords: quince, Cydonia oblonga Mill., pretreatment, blanching, ascorbic acid, enzymatic browning, drying performance, vitamin C, product quality.

1. Introduction

Quince (Cydonia oblonga Mill.) is a valuable fruit crop with considerable potential for processing due to its nutritional composition and technological properties. Quince fruits contain sugars, organic acids, pectic substances, vitamins, minerals, phenolic compounds, and

other biologically active constituents. The relatively high dry matter and pectin contents make quince a promising raw material for the production of various processed products, including dried fruits.

Drying is one of the most widely used preservation methods for extending the shelf life of fruit products. By reducing moisture content and water activity, drying limits microbial development and slows biochemical deterioration. At the same time, an appropriately designed drying process should preserve the nutritional, physicochemical, and sensory characteristics of the raw material as much as possible.

However, the specific structural characteristics of quince fruit create technological challenges during drying. Quince tissue is relatively dense and mechanically firm, which may restrict moisture migration from the inner layers of the fruit to its surface. Consequently, conventional drying may require prolonged processing times and relatively high energy consumption.

Another important problem arises immediately after cutting the fruit. Mechanical disruption of cellular tissues increases their exposure to atmospheric oxygen and promotes the activity of oxidative enzymes, particularly polyphenol oxidase. This may result in rapid enzymatic browning and deterioration of the natural colour and visual quality of the final dried product.

Pretreatment prior to drying is therefore an important technological step for controlling these undesirable changes. Cutting fruit into appropriately sized pieces reduces the distance required for moisture diffusion and can enhance heat and mass transfer. Blanching can partially inactivate enzymes responsible for browning, while antioxidant treatments may suppress oxidative reactions and improve colour stability.

Ascorbic acid is particularly useful as an antioxidant treatment because of its ability to limit oxidation processes in cut fruit tissues. Nevertheless, pretreatment conditions must be carefully selected. Excessive blanching temperature or treatment duration may lead to undesirable softening of fruit tissues and increased losses of water-soluble nutrients, including vitamin C. Therefore, slicing thickness, blanching temperature and duration, and antioxidant concentration should be considered as interconnected technological parameters.

Recent developments in fruit processing have also increased interest in combining pretreatment techniques with more energy-efficient drying technologies. In particular, combining convective heat transfer with infrared energy can intensify moisture removal, shorten processing time, and potentially reduce energy consumption compared with conventional drying alone.

Cultivar characteristics should also be considered when developing a drying technology. Differences in dry matter content, sugar concentration, organic acid composition, tissue structure, and initial moisture content may affect drying kinetics, product yield, nutrient retention, and sensory characteristics. Therefore, identifying cultivars that respond favourably to pretreatment and drying is important for developing an efficient quince-processing technology.

The **objective of this study** was to evaluate the influence of slicing, blanching, and ascorbic acid pretreatment on enzymatic browning, vitamin C retention, drying performance, and the quality characteristics of different quince cultivars and to identify technologically suitable pretreatment and drying conditions for producing high-quality dried quince products.

2. Materials and Methods

2.1. Plant Material

Seven quince (Cydonia oblonga Mill.) cultivars were used as experimental materials: **Samarqand yirik mevasi, Toshkent yumaloq behi, Andijon behi, Qoqon behi, Dessertnaya, Krupnoplodnaya, and Maslyanka Pozdnyaya**.

The fruits selected for the experiments were visually inspected and samples with mechanical damage, disease symptoms, or other visible defects were excluded. The selected fruits were washed and prepared for subsequent pretreatment and drying experiments. The experiments were conducted under laboratory and semi-industrial conditions during **2023–2025**, with experimental treatments performed in 3–4 replications.

2.2. Sample Preparation and Pretreatment

Before drying, quince fruits were cut into slices of uniform thickness. Preliminary experiments included cutting thicknesses ranging from 5 to 10 mm and different cutting configurations. Based on the technological evaluation, **5–7 mm thick slices** were selected for further experiments.

Three principal pretreatment approaches were considered: blanching, antioxidant treatment, and their combined application. Untreated fruit slices were used as the control.

Blanching was carried out in hot water at temperatures ranging from 80 to 90 °C. Based on the experimental results, treatment at **85–90 °C for 2–3 min** was selected as the most appropriate regime for subsequent evaluation.

Ascorbic acid was used as an antioxidant to suppress oxidative reactions in the cut fruit tissue and improve natural colour preservation. In the selected combined pretreatment, fruit slices were blanched at 85–90 °C for 2–3 min and subsequently treated with a **0.3% ascorbic acid solution**.

The experimental pretreatment scheme is presented in Table 1.

Table 1. Experimental pretreatment scheme for quince fruit

Treatment	Slice thickness	Blanching treatment	Antioxidant treatment	Technological description
Control	5–7 mm	Not applied	Not applied	Untreated sample
Treatment I	5–7 mm	80–85 °C, 2–3 min	Not applied	Thermal pretreatment
Treatment II	5–7 mm	Not applied	Ascorbic acid	Antioxidant pretreatment
Treatment III	5–7 mm	85–90 °C, 2–3 min	0.3% ascorbic acid	Combined pretreatment

The combined pretreatment was intended to reduce enzymatic activity through blanching while simultaneously limiting oxidative deterioration through the antioxidant effect of ascorbic acid.

2.3. Drying Procedure

The pretreated quince samples were subjected to drying using convective, infrared, and combined drying approaches. Particular attention was paid to the combined method, in which convective hot-air treatment and infrared energy were applied within the drying process.

For the selected technological regime, a drying temperature of **65 °C** and an air velocity of **1.5 m/s** were used. The drying process was continued until the required final moisture level was achieved.

The technological performance of drying was evaluated using the following parameters: drying duration, h; final moisture content, %; dried product yield, %; reduction in drying time, %; reduction in energy consumption, %.

The use of these indicators allowed the drying responses of the seven quince cultivars to be compared under similar technological conditions.

2.4. Biochemical and Quality Evaluation

The initial biochemical characteristics of the quince cultivars were evaluated using the following indicators: dry matter content, %; total sugars, %; organic acids, %; vitamin C content, mg/100 g; pectin content, %.

The effectiveness of pretreatment was assessed according to the reduction in enzymatic browning, improvement in natural colour preservation, vitamin C loss, and vitamin C retention.

The sensory quality of the dried quince products was evaluated using a **5-point scale**. Colour, taste, aroma, texture, and overall acceptability were considered the principal sensory attributes.

2.5. Evaluation of Technological Efficiency

The technological suitability of the cultivars was assessed by considering the relationship between their initial biochemical composition and drying performance. Particular attention was given to dry matter content because cultivars with a higher proportion of dry matter generally require removal of a smaller relative amount of water and may therefore provide a higher yield of dried product.

The efficiency of combined drying was assessed in comparison with the corresponding conventional drying approach. The reduction in drying duration and energy consumption, together with final product yield and moisture content, was used to identify cultivars showing the most favourable technological response.

2.6. Statistical Analysis

The experiments were performed in **3–4 replications**. The experimental data were evaluated using analysis of variance (ANOVA). Differences among experimental treatments were assessed using the $\mathbf{LSD_{0.05}}$ criterion.

3. Results and Discussion

3.1. Initial Biochemical Characteristics of Quince Cultivars

The initial biochemical composition of the fruit is an important factor affecting its technological suitability for drying. Differences in dry matter, sugars, organic acids, vitamin C, and pectin may influence moisture removal, dried product yield, nutritional value, and the overall quality of the final product.

The results showed considerable differences among the investigated quince cultivars. The biochemical characteristics of the seven cultivars are presented in Table 2.

Table 2. Initial biochemical characteristics of quince cultivars (2023–2025)

Cultivar	Dry matter, %	Total sugars, %	Organic acids, %	Vitamin C, mg/100 g	Pectin, %
Samarqand yirik mevasi	18.1	10.2	1.42	23.8	3.10

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Toshkent yumaloq behi	16.1	9.1	1.55	21.4	2.72
Andijon behi	16.7	9.8	1.38	22.1	2.80
Qoqon behi	17.8	10.1	1.46	23.2	3.02
Dessertnaya	**18.8**	**10.6**	1.31	**24.6**	2.94
Krupnoplodnaya	18.3	10.0	1.40	22.8	2.96
Maslyanka Pozdnyaya	17.4	9.5	1.63	21.9	2.85

Among the investigated cultivars, **Dessertnaya** had the highest dry matter content (18.8%) and total sugar concentration (10.6%). It also showed the highest vitamin C content, reaching 24.6 mg/100 g. Samarqand yirik mevasi and Krupnoplodnaya also contained relatively high levels of dry matter, at 18.1 and 18.3%, respectively.

Qoqon behi was characterised by 17.8% dry matter and 10.1% total sugars, indicating favourable properties for further processing. In contrast, Toshkent yumaloq behi had the lowest dry matter content (16.1%) and the lowest total sugar content (9.1%) among the cultivars evaluated.

A higher initial dry matter content is technologically advantageous for drying because a smaller relative proportion of water must be removed to obtain a stable dried product. This may contribute to a higher mass yield after drying. The observed differences among the cultivars therefore indicate that cultivar selection should be regarded as an integral component of quince drying technology.

3.2. Effect of Pretreatment on Enzymatic Browning and Vitamin C Retention. The combined pretreatment consisting of slicing, blanching, and ascorbic acid treatment produced different responses among the seven quince cultivars. The most important differences were observed in enzymatic browning, natural colour preservation, and vitamin C retention.

Blanching at 85–90 °C for 2–3 min contributed to the reduction of oxidative enzyme activity, whereas treatment with ascorbic acid helped suppress subsequent oxidation reactions. Their combined application therefore provided a technological basis for controlling quality deterioration before and during drying.

The cultivar-specific results are presented in Table 3.

The most favourable response was observed in **Samarqand yirik mevasi**, where enzymatic browning was reduced by 48.0% and colour preservation improved by 45.0%. Vitamin C loss was limited to 12.0%, resulting in a retention level of 88.0%.

Table 3. Effect of pretreatment on enzymatic browning and vitamin C retention in quince cultivars (2023–2025)

Cultivar	**Reduction in enzymatic browning, %**	**Improvement in colour preservation, %**	**Vitamin C loss, %**	**Vitamin C retention, %**
Samarqand yirik mevasi	**48.0**	**45.0**	**12.0**	**88.0**
Toshkent yumaloq behi	41.3	38.6	16.8	83.2
Andijon behi	39.7	37.2	17.5	82.5

Qoqon behi	**46.2**	**43.8**	**13.4**	**86.6**
Dessertnaya	44.1	42.0	14.6	85.4
Krupnoplodnaya	43.5	41.2	15.1	84.9
Maslyanka Pozdnyaya	40.5	38.1	16.3	83.7

Qoqon behi also demonstrated a strong response to pretreatment. Enzymatic browning decreased by 46.2%, while colour preservation improved by 43.8%. Vitamin C retention reached 86.6%, with a corresponding loss of only 13.4%.

Dessertnaya also responded favourably, showing a 44.1% reduction in enzymatic browning and 85.4% vitamin C retention. Krupnoplodnaya exhibited comparable values, with browning reduced by 43.5% and vitamin C retention reaching 84.9%.

The differences among cultivars may be associated with variation in tissue structure, initial biochemical composition, and the activity of oxidative enzymes. The results indicate that the effectiveness of a pretreatment regime cannot be considered independently of cultivar characteristics.

From a technological perspective, Samarqand yirik mevasi and Qoqon behi showed the most favourable combination of colour stability and vitamin C preservation. These cultivars therefore appear particularly suitable for the production of dried quince products where retention of natural appearance and nutritional quality is a priority.

3.3. Drying Performance of Quince Cultivars. The drying stage revealed clear differences in the technological response of the investigated quince cultivars. The combined drying approach, integrating convective hot-air treatment with infrared energy, was applied to enhance moisture removal and improve process efficiency.

The technological performance of each cultivar was evaluated according to drying duration, final moisture content, dried product yield, reduction in drying time, and reduction in energy consumption. The results are presented in Table 4.

The highest drying efficiency was observed in **Dessertnaya**. Its drying time was 9.8 h, the shortest among the cultivars evaluated, while the final moisture content reached 12.2%. This cultivar also produced the highest dried product yield of 19.8%. The reduction in drying time reached 22.0%, accompanied by a 15.0% reduction in energy consumption.

Table 4. Technological parameters of combined drying of quince cultivars (2023–2025)

Cultivar	**Drying time, h**	**Final moisture, %**	**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
Qoqon behi	10.1	12.4	19.1	20.0	14.1
Dessertnaya	**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

Krupnoplodnaya showed a similarly favourable technological response. Drying was completed in 9.9 h, with a final moisture content of 12.3% and a product yield of 19.5%. Compared with the conventional approach, drying time and energy consumption were reduced by 21.3 and 14.7%, respectively.

Samarqand yirik mevasi and Qoqon behi also demonstrated favourable drying characteristics. Product yields reached 19.3% and 19.1%, respectively. Qoqon behi showed a 20.0% reduction in drying time and a 14.1% reduction in energy consumption.

In contrast, Toshkent yumaloq behi required the longest drying time (10.8 h) and produced the lowest dried product yield (17.6%). Andijon behi and Maslyanka Pozdnyaya showed intermediate technological performance.

The observed differences can be partly related to the initial composition of the fruit. Cultivars with relatively high dry matter contents generally produced higher dried product yields. Dessertnaya, for example, contained 18.8% initial dry matter and provided a dried product yield of 19.8%, whereas Toshkent yumaloq behi contained 16.1% dry matter and produced a yield of 17.6%.

The results therefore indicate that drying technology should not be considered independently of cultivar characteristics. The selection of cultivars with favourable initial composition can contribute to higher product yield and more efficient utilisation of thermal energy.

The combined application of convective and infrared energy also provided a technological advantage by intensifying heat and mass transfer. Convective airflow facilitated the removal of moisture from the product surface, while infrared energy promoted heat transfer into the fruit tissue. Their combined effect contributed to shorter drying times and lower energy requirements.

Overall, the combined drying process reduced drying duration by approximately **18–22%** in the most responsive cultivars and provided an energy saving of up to **12–15%**, indicating its potential for improving the efficiency of dried quince production.

3.4. Sensory Quality of Dried Quince Products. Sensory quality is an important criterion in determining the practical suitability of a drying technology. Although technological efficiency is essential, a shorter drying process is only advantageous when the resulting product retains acceptable colour, taste, aroma, and texture.

The dried quince samples were evaluated using a 5-point sensory scale. The results are presented in Table 5.

Table 5. Sensory characteristics of dried quince products (2023–2025), points

Cultivar	Colour	Taste	Aroma	Texture	Overall score
Samarqand yirik mevasi	**4.8**	4.7	4.6	**4.8**	**4.73**
Toshkent yumaloq behi	4.4	4.3	4.3	4.4	4.35
Andijon behi	4.3	4.5	4.4	4.2	4.35
Qoqon behi	4.7	**4.8**	4.7	4.7	**4.73**
Dessertnaya	4.6	**4.8**	**4.8**	4.4	4.65
Krupnoplodnaya	4.5	4.6	4.5	**4.8**	4.60
Maslyanka Pozdnyaya	4.3	4.4	4.4	4.5	4.40

The highest overall sensory scores were obtained for **Samarqand yirik mevasi and Qoqon behi**, both reaching 4.73 points. Samarqand yirik mevasi received the highest colour score of 4.8 and maintained a high texture score of 4.8, indicating good preservation of appearance and structural characteristics during processing.

Qoqon behi showed particularly favourable taste characteristics, reaching 4.8 points, while its colour, aroma, and texture scores ranged from 4.7 to 4.8.

Dessertnaya received an overall score of 4.65 and showed particularly high scores for taste and aroma, both reaching 4.8 points. Krupnoplodnaya achieved an overall score of 4.60 and was distinguished by its texture score of 4.8.

These results demonstrate that the cultivar showing the highest drying efficiency does not necessarily provide the highest overall sensory score. Dessertnaya and Krupnoplodnaya were technologically advantageous in terms of drying duration and product yield, whereas Samarqand yirik mevasi and Qoqon behi showed the highest overall sensory acceptance.

This distinction is important for practical processing. Selection of a cultivar should therefore depend on the intended production objective. Where process efficiency and product yield are prioritised, Dessertnaya and Krupnoplodnaya may be advantageous. Where natural appearance and overall sensory quality are the main criteria, Samarqand yirik mevasi and Qoqon behi appear more suitable.

3.5. Overall Technological Assessment

A comprehensive evaluation of the results showed that the efficiency of quince drying is determined by the interaction of three major factors: **cultivar characteristics, pretreatment conditions, and drying regime**.

Pretreatment with blanching and ascorbic acid was particularly effective for Samarqand yirik mevasi and Qoqon behi, where enzymatic browning was reduced and vitamin C retention remained high. In contrast, Dessertnaya and Krupnoplodnaya showed the greatest technological advantages during combined drying.

Thus, the results suggest that applying a single processing regime without considering cultivar characteristics may not provide the highest overall efficiency. A cultivar-specific approach can allow processors to balance drying duration, energy requirements, product yield, nutrient retention, and sensory quality.

4. Conclusion

The results of the study demonstrated that the technological suitability of quince (Cydonia oblonga Mill.) for drying depends on cultivar characteristics, initial biochemical composition, pretreatment conditions, and the drying method applied.

Among the seven cultivars investigated, Samarqand yirik mevasi, Qoqon behi, and Dessertnaya showed favourable characteristics for drying and processing. Dried product yield in the technologically promising cultivars ranged from **17.5 to 19.8%**.

Pretreatment consisting of slicing the fruits into **5–7 mm thick pieces**, blanching at **85–90 °C for 2–3 min**, and treatment with a **0.3% ascorbic acid solution** provided favourable conditions for preserving product quality. The treatment improved natural colour preservation by **40–45%** and maintained vitamin C retention at **85–88%**.

Samarqand yirik mevasi and Qoqon behi responded particularly well to pretreatment. Enzymatic browning was reduced by **42–48%**, while vitamin C losses were limited to **12–15%**.

The combined convective–infrared drying method demonstrated favourable technological performance. Dessertnaya and Krupnoplodnaya showed the greatest reductions in drying duration, reaching **18–22%**, while dried product yield was within the range of **17.5–19.8%**. The combined drying approach also reduced energy consumption by approximately **12–15%**.

A drying temperature of **65 °C** and an air velocity of **1.5 m/s** were identified as effective technological conditions. Under the selected regime, dried products obtained from Samarqand yirik mevasi and Qoqon behi achieved sensory scores within the range of **4.6–4.8 points**.

The findings indicate that an integrated approach combining **cultivar selection, appropriate pretreatment, and an efficient drying regime** is preferable to the application of a uniform drying procedure for all quince cultivars. Samarqand yirik mevasi and Qoqon behi were particularly favourable in terms of colour preservation, vitamin C retention, and sensory quality, whereas Dessertnaya and Krupnoplodnaya demonstrated advantages in drying efficiency and product yield.

For practical production of dried quince, the use of Samarqand yirik mevasi, Qoqon behi, and Dessertnaya cultivars can therefore be recommended, with appropriate pretreatment followed by combined convective–infrared drying.

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