INFLUENCE OF DRYING TEMPERATURE ON DEHYDRATION EFFICIENCY OF PUMPKIN AND SESAME BY-PRODUCTS

Sardorbek U.Isroilov
In Independent Researcher, Tashkent State Agrarian University
Tashkent, Uzbekistan
https://orcid.org/(0009-0008-3144-2414)
sardorbek97isroilov@gmail.com
+99888 007 32 97
https://doi.org/10.5281/zenodo.22252286

Abstract

The growing volume of agricultural production and food processing generates considerable quantities of plant-derived by-products that remain insufficiently utilized. Pumpkin processing residues and non-seed sesame biomass are of particular interest because they contain valuable structural carbohydrates and may serve as alternative raw materials for feed production. However, their relatively high initial moisture content limits storage stability and requires appropriate dehydration prior to further processing.

This study investigated the effect of convective drying temperature on the dehydration efficiency of pumpkin processing residues, sesame flowers, and sesame stems. The materials were dried at 50, 60, and 70°C at a constant air velocity of 1.0 m/s until a final moisture content of 8–10% was achieved. Drying duration, final moisture content, and dry product yield were used as the main technological evaluation criteria.

Increasing the drying temperature significantly accelerated moisture removal in all investigated materials. The drying time of pumpkin residues decreased from 390 min at 50°C to 305 min at 60°C and 245 min at 70°C. For sesame flowers, the corresponding values were 315, 245, and 195 min, while sesame stems required 265, 205, and 165 min, respectively. Compared with the 50°C treatment, drying at 60°C reduced process duration by approximately 21.8–22.6%. Differences in dehydration behavior were associated with the initial moisture content and structural characteristics of the raw materials.

Although drying at 70°C provided the shortest processing time, a moderate temperature of 60°C was considered more appropriate for further processing of the investigated plant materials, taking into account the need to balance drying intensity with preservation of raw-material quality. The results provide a technological basis for converting pumpkin and sesame by-products into stable powdered ingredients suitable for further use in feed production.

Keywords: pumpkin processing residues, sesame flowers, sesame stems, agricultural by-products, convective drying, drying temperature, dehydration efficiency, feed ingredients.

1. Introduction

The efficient utilization of agricultural and food-processing by-products has become an important component of sustainable and resource-efficient production systems. Considerable quantities of plant biomass generated during harvesting and processing are still discarded or used inefficiently despite containing valuable structural and functional components. The conversion of such materials into stable secondary raw materials can reduce waste accumulation while providing additional resources for food and feed production [1, 2].

Pumpkin processing generates peel, fibrous tissues, and other residual fractions that retain considerable amounts of dietary fiber and pectic substances [1, 2]. These by-products are characterized by high moisture content immediately after processing, which restricts their storage stability and increases susceptibility to microbial and enzymatic deterioration. Therefore, appropriate stabilization is required before pumpkin residues can be milled or incorporated into feed formulations.

Sesame (Sesamum indicum L.) is primarily cultivated for its oil-rich seeds, whereas its vegetative biomass receives considerably less technological attention. Sesame stems and other crop residues contain substantial structural components and may represent an underutilized source of secondary agricultural raw materials [6, 7]. Their further processing may contribute to a more complete utilization of sesame biomass and reduce the volume of agricultural residues remaining after production.

Drying is one of the most widely used methods for stabilizing moisture-rich biological materials. Reduction of moisture content restricts microbial activity, facilitates storage and transportation, and enables subsequent milling into stable powdered products. Convective hot-air drying is particularly attractive for agricultural raw materials because of its relatively simple equipment and controllable operating conditions [3].

Drying temperature is a major factor controlling the rate of heat and mass transfer. Higher air temperatures generally increase the moisture-removal rate and shorten processing time. However, intensive thermal exposure can cause undesirable changes in the physical, chemical, and functional characteristics of plant-derived materials [3, 5]. Therefore, optimization of the drying process should not be based exclusively on the shortest possible dehydration time.

The technological characteristics of the raw material itself are also important. Initial moisture content, tissue structure, particle dimensions, and chemical composition influence moisture migration and consequently determine drying behavior. For agricultural by-products intended for further use as feed ingredients, an appropriate drying regime should provide sufficient dehydration while maintaining the technological and nutritional value of the material [3, 4].

Therefore, the **aim of this study** was to evaluate the effect of convective drying temperature on the dehydration characteristics of pumpkin processing residues, sesame flowers, and sesame stems and to identify an appropriate temperature regime based on drying duration, final moisture content, and dry product yield.

2. Materials and Methods

The study was conducted using three types of plant-derived secondary raw materials: pumpkin processing residues, sesame flowers, and sesame stems. Pumpkin residues consisted mainly of peel and fibrous tissues remaining after primary processing. Prior to drying, all materials were cleaned of foreign matter and prepared to obtain relatively uniform samples. Pumpkin residues and sesame stems were reduced to a uniform size to facilitate consistent heat and mass transfer during dehydration.

The initial moisture contents of pumpkin processing residues, sesame flowers, and sesame stems were **86.4 ± 1.2%, 79.1 ± 1.0%, and 67.3 ± 0.9%**, respectively.

Convective drying was performed at three air temperatures — **50, 60, and 70°C** — while air velocity was maintained at **1.0 m/s**. Drying was continued until the samples reached a final moisture content of approximately **8–10%**. Sample mass was monitored periodically during the process to assess moisture removal and determine the end point of drying.

The experimental treatments were designated as D50, D60, and D70 according to the applied drying temperature. Each experiment was performed in triplicate. Drying duration, final moisture content, and dry product yield were considered the main technological indicators.

After drying, the samples were cooled to ambient temperature and weighed. Results were expressed as mean ± standard deviation. Differences among drying treatments were evaluated statistically, with significance accepted at $p < 0.05$.

3. Results and Discussion

The initial moisture content differed considerably among the investigated materials and had a pronounced influence on their drying behavior. Pumpkin processing residues contained 86.4% moisture, compared with 79.1% in sesame flowers and 67.3% in sesame stems. Consequently, pumpkin residues required the longest drying period under all investigated temperature regimes.

Increasing the drying temperature from 50 to 70°C consistently accelerated moisture removal. This response agrees with the general principles of convective dehydration, according to which an increase in drying-air temperature enhances heat transfer and increases the vapor-pressure gradient between the product and surrounding air, thereby accelerating moisture migration [3].

Table 1. Effect of convective drying temperature on dehydration characteristics of pumpkin and sesame by-products

Raw material	Temperature, °C	Drying time, min	Final moisture, %	Dry product yield, %
Pumpkin processing residues	50	390 ± 12	9.4 ± 0.3	14.8 ± 0.4
	60	**305 ± 10**	**8.9 ± 0.3**	**14.6 ± 0.4**
	70	245 ± 9	8.4 ± 0.2	14.3 ± 0.3
Sesame flowers	50	315 ± 10	9.2 ± 0.3	22.7 ± 0.5
	60	**245 ± 8**	**8.7 ± 0.2**	**22.5 ± 0.5**

	70	195 ± 7	8.2 ± 0.2	22.2 ± 0.4
Sesame stems	50	265 ± 9	9.5 ± 0.3	35.1 ± 0.6
	60	**205 ± 7**	**8.9 ± 0.3**	**34.9 ± 0.5**
	70	165 ± 6	8.3 ± 0.2	34.5 ± 0.5

For pumpkin processing residues, drying time decreased from 390 min at 50°C to 305 min at 60°C and 245 min at 70°C. Thus, increasing the temperature from 50 to 60°C shortened processing time by **21.8%**, while treatment at 70°C produced a **37.2% reduction**. Previous studies of pumpkin-derived materials have similarly demonstrated that their processing characteristics are strongly influenced by moisture content and treatment conditions [1, 2].

Sesame flowers showed a comparable temperature-dependent response. Drying required 315 min at 50°C, 245 min at 60°C, and 195 min at 70°C. Therefore, the D60 treatment reduced processing time by **22.2%** compared with D50.

The shortest drying periods were observed for sesame stems. Their dehydration time decreased from 265 min at 50°C to 205 min at 60°C and 165 min at 70°C. The relatively rapid moisture removal can partly be attributed to the lower initial moisture content of the stems. Previous investigations have shown that sesame stems are characterized by a high proportion of structural components, particularly cellulose and other fibrous fractions [6]. Studies of sesame crop residues also indicate that this biomass has potential for further agricultural utilization rather than being treated exclusively as waste [7].

All drying treatments reduced the moisture content to **8.2–9.5%**, demonstrating that the three temperature regimes were technically capable of producing sufficiently dehydrated materials for subsequent processing. However, achieving the lowest final moisture level does not necessarily indicate the most appropriate treatment because product quality and energy requirements should also be considered.

Dry product yield varied substantially among raw materials but only slightly among drying temperatures within each material. Sesame stems provided the highest dry product yield, ranging from 34.5 to 35.1%, whereas pumpkin residues yielded 14.3–14.8%. This difference primarily reflects variations in the initial dry matter content of the materials.

From a kinetic perspective, 70°C was the most effective treatment because it provided the shortest drying time. Nevertheless, intensive thermal processing can negatively affect heat-sensitive constituents and functional characteristics of plant materials [3, 5]. Preservation of dietary fiber and other valuable components is particularly relevant when dried agricultural residues are intended for feed applications [4].

For this reason, the D60 treatment appears to provide a more appropriate technological compromise. Compared with drying at 50°C, the use of 60°C shortened processing time by **21.8–22.6%** for all investigated materials while allowing the final moisture content to remain below 9%. At the same time, this treatment avoided the more intensive thermal exposure associated with the 70°C regime.

Overall, the findings demonstrate that the dehydration behavior of agricultural by-products is determined by the interaction between processing temperature and raw-material properties. Selection of drying conditions should therefore consider not only process duration but also the intended subsequent utilization of the dried material. In the present study, convective drying at **60°C and an air velocity of 1.0 m/s** provided the most appropriate conditions for preparing pumpkin and sesame by-products for subsequent milling and potential use as feed ingredients.

4. Conclusion

The results demonstrated that drying temperature significantly affected the dehydration performance of pumpkin processing residues, sesame flowers, and sesame stems. Increasing the air temperature from 50 to 70°C accelerated moisture removal and reduced drying time in all investigated materials. The magnitude of the drying response also depended on the initial moisture content and structural characteristics of the raw material.

Pumpkin processing residues required the longest dehydration period because of their high initial moisture content, whereas sesame stems showed the shortest drying time. Increasing the temperature from 50 to 60°C reduced drying duration by 21.8% for pumpkin residues, 22.2% for sesame flowers, and 22.6% for sesame stems. All samples dried at 60°C reached a final moisture content below 9%, which is suitable for subsequent milling and storage.

Although drying at 70°C resulted in the shortest processing time, the 60°C treatment at an air velocity of 1.0 m/s provided a more appropriate technological balance between process intensification and moderate thermal exposure. This regime can therefore be recommended for the convective drying of the investigated plant by-products prior to their conversion into powdered feed ingredients.

The results confirm the potential for processing pumpkin and sesame-derived residues into stable secondary raw materials and provide a technological basis for their more efficient utilization in feed production. Further research should focus on energy consumption during drying and the effects of the selected regime on the nutritional and functional properties of the resulting feed powders.

References:

1.de Escalada Pla, M. F., Ponce, N. M., Stortz, C. A., Gerschenson, L. N., & Rojas, A. M. (2007). Composition and functional properties of enriched fiber products obtained from pumpkin (Cucurbita moschata Duchesne ex Poiret). LWT – Food Science and Technology, 40(7), 1176–1185.

2.Lalnunthari, C., Devi, L. M., & Badwaik, L. S. (2020). Extraction of protein and pectin from pumpkin industry by-products and their utilization for developing

edible film. Journal of Food Science and Technology, 57(5), 1807–1816. https://doi.org/10.1007/s13197-019-04214-6
3.Sagar, V. R., & Kumar, P. S. (2010). Recent advances in drying and dehydration of fruits and vegetables: A review. Journal of Food Science and Technology, 47(1), 15–26.
4.Dhingra, D., Michael, M., Rajput, H., & Patil, R. T. (2012). Dietary fibre in foods: A review. Journal of Food Science and Technology, 49(3), 255–266.
5.Figiel, A., & Michalska, A. (2017). Overall quality of fruits and vegetables products affected by the drying processes with the assistance of vacuum-microwaves. International Journal of Molecular Sciences, 18(1), 71.
6.Gebremedhin, G. H., et al. (2020). Potential, quality and quantity assessment of sesame plant residue in dry land vertisols of Tigrai, Ethiopia: Approach for sustainability of dry-land farming. Heliyon, 6, e05287.Umidov Sh.E., Genjebaev M.S. The influence of technologial properties on the quality of pumpkin fruits during storage // "Academic zone"(November, 2023). – India, 2023. – Volume 2. – Issue 12. – P. 477-484
7. Genjebayev M.S., Umidov Sh.E. Qovoq mevalarini quritib, undan kukun tayyorlashning texnologik koʻrsatkichlari // "Agro kimyo himoya va oʻsimliklar karantini" jurnalui. – Toshkent, 2025. – № 4 (112). – B. 76-80 (06.00.00; № 12).
8.Genjebayev M.S., Umidov Sh.E. Qovoq mevalarini quritib tayyorlangan kukun mahsulotlarini qadoqlash usullari // "Agro kimyo himoya va oʻsimliklar karantini" jurnalui. – Toshkent, 2025. – № 4 (112). – B. 81-83 (06.00.00; № 12).