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Research Article

# Determination of Quality Properties of Dried Purple Potatoes

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**ABSTRACT**

In this study, the effects of different drying methods on the physical properties and antioxidant properties of purple potato powders obtained by freeze drying and hot air drying were investigated. The purple potatoes were mashed, and the mashed samples were dried using hot air (oven) and freeze-drying (lyophilizer) methods. The obtained purple potato powder samples were analyzed for moisture content, water activity, wettability, color measurements and antioxidants. The results of the analyses showed that the moisture content, water content, wettability and color and antioxidant values of the powdered purple potato samples obtained by freeze drying gave better industrial and nutritional results. It was determined that freeze drying process is more suitable for the production of purple potato powder.

**Keywords:** Purple potato, freeze drying, oven drying, antioxidant activity, physical properties

## Kurutulmuş Mor Patateslerin Kalite Özelliklerinin Belirlenmesi

**ÖZ**

Bu çalışmada, dondurarak kurutma ve sıcak hava kurutma yöntemi kullanılarak elde edilen mor patates tozlarının fiziksel özellikleri ve antioksidan özellikleri üzerine farklı kurutma yöntemlerinin etkileri incelenmiştir. Mor patates püre haline getirilerek dondurularak (liyofilizatör) ve sıcak hava (etüv) kurutulmuştur. Elde edilen mor patates tozu örneklerinde nem içeriği, su aktivitesi, ıslanabilirlik, renk ölçümleri ve antioksidan analizleri yapılmıştır. Analiz sonuçlarında nem, su içeriği, akabilirlik ve renk değerleri ile antioksidan değerlerinin dondurularak kurutma sonucu elde edilen toz mor patates örneklerinde endüstriyel ve besinsel olarak daha iyi sonuçlar elde edilmiştir. Dondurularak kurutma prosesinin mor patates tozu üretimi için daha uygun olduğu belirlenmiştir.

**Anahtar kelimeler:** Mor patates, dondurarak kurutma, sıcak hava kurutma, antioksidan aktivite, fiziksel özellikler

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## Introduction

In recent years, purple sweet potato has been recognized as a beneficial food crop worldwide due to its high nutritional potential (Guo et al., 2019). Nowadays, sweet potato cultivation has spread worldwide due to its great adaptability to different climatic conditions. It is tolerant to relatively low temperatures at high altitudes, but is very sensitive to freezing temperatures (Lim, 2016). Edible roots are long and conical in shape, with flesh of various colors and a smooth skin (Jain et al., 2015). The purple potato (Solanum tuberosum) has recently become a cultivated plant that has gained popularity among healthy food options and attracts attention with its nutritional values. This type of potato stands out for its rich composition of anthocyanins, vitamins and minerals that provide many health benefits. In particular, the anthocyanin content of purple potatoes plays an important role as the source of their color; these pigments are known for their high antioxidant properties (Mesiano et al., 2024). Purple sweet potatoes are used not only as food but also as a natural colorant in the food industry. In particular, it serves as a coloring agent in food and beverage products (Mahfud & Kusuma, 2016). In addition, purple sweet potato flours are used to enhance flavor and nutritional value in various baked goods and desserts (Mahfud & Kusuma, 2016).

The flesh color varies from white to orange and purple. Purple sweet potatoes (Ipomoea batatas) are a type of potato with a distinctive purple color due to the presence of anthocyanins, natural pigments with antioxidant properties. Studies have shown that purple sweet potatoes contain bioactive molecules with a variety of health benefits, including antioxidant and potential anti-cancer effects. Overall, purple sweet potatoes are a versatile and nutritious food source with promising health-promoting properties that make them a valuable addition to a variety of food and health products. Purple sweet potatoes not only contribute to your health, but also stand out with nutritious properties.

Fresh fruits and vegetables with high moisture content maintain their vitality for a certain period of time after harvest. Therefore, products can deteriorate quickly when storage conditions are not suitable. Many preservation methods are used to prevent rapid deterioration of foods after harvest and to increase their durability. The most commonly used of these methods is drying foods. In drying foods, different drying methods such as sun drying, microwave drying, spray drying, freeze drying are used. (Talih & Dirim, 2018)

Drying fruits and vegetables in particular makes them consumable for a longer period of time and generally extends their shelf life (Çerçi & Hürdoğan 2020). Hot air drying, which is applied in the food industry to extend the shelf life of foods while preserving their nutritional value, involves drying foods with air temperature. This method is widely used in the food industry (Ersoy et al., 2017). Hot air drying is considered an effective method in the processing of many types of foods. Freeze drying allows foods to be dried by freezing and then subliming water at low pressure. This method allows the best preservation of nutritional values and ensures that products are of similar quality to fresh foods (Metiner & Ersus, 2023). Although freeze drying is generally costly, it is preferred in terms of obtaining high-quality products. There are various drying methods in the literature and studies on drying fruits and vegetables (Zhao et al., 2024; Ntuli et al., 2017; Chandel et al., 2021; Hooshmand et al., 2011; Cho & Kim, 2015; Richard et al., 2015; Kowalska et al., 2018).

In this study, the physical and antioxidant properties of purple potato powders obtained by two different drying methods (freeze drying and hot air (oven) drying) were determined. Bulk density, tapped density, wettability, water content, water activity, water absorption capacity, water solubility index and antioxidant activities of the powders obtained by freeze and hot air drying were determined.

## Material and Methods

### Material

Purple potatoes were obtained September (2024) and stored in the refrigerator at +4 C until use. Purple sweet potatoes used in the study were obtained from the Hatay region (registered by İlkmoru).

### Preparation of samples

Purple sweet potatoes were washed and sterilized by immersion in a sodium hypochlorite solution (200 ppm for 15 minutes). They were then peeled and cut into thin slices approximately 5 cm² in size. Purple sweet potatoes were heat treated by immersing in water at 80 °C for 10 minutes (Fig 1). After heat treatment, the potatoes were blended with the cooking water in a bench type blender (Waring Commercial Blender, USA) for 10 minutes to obtain a puree (Cunha et al., 2023). Some of the mashed potatoes (Fig 2) were placed in plastic packages for drying in a lyophilizer and the rest in an oven.

**Figure 1.** Heat treatment of purple sweet potato

#### *Freeze drying (Lyophilization)*

The prepared purple mashed potatoes were dried using a freeze dryer (Biobase BK-FD 18P, Biobase Biosun Co. Ltd, China) and a condenser set at -70/-80 °C for an average of 5 days. After lyophilization, the powdered samples (Fig 2) were stored at 4 °C storage temperature until use.

#### *Hot air (Oven) drying*

An oven (NUVE, FN 400, Türkiye) was used to dry the prepared purple potato puree at 80 °C until the moisture content was within the permissible range (Processed for about 4-5 hours until the final moisture content was less than 3) for powder samples. Until they were used, the dried purple potato powders (Fig 2) were kept at 4 °C.

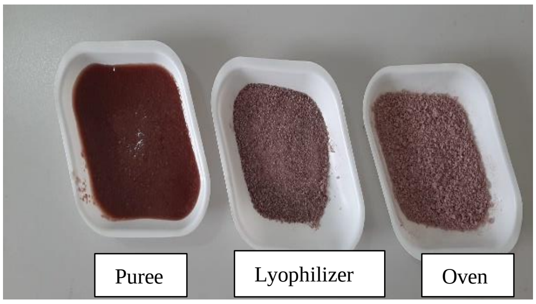


**Figure 2**. Puree and dried potato powders

### Physical analysis of powder

#### *Moisture determination and water activity*

An infrared moisture analyzer (XM 120; Precisa Instruments Ltd, Switzerland) was used to measure the moisture contents. A water activity meter (Rotronic Hygropalm, Bassersdorf, Switzerland) was used to measure changes in water activity (aw) values at 25 °C. Analyses were performed in triplicate.

#### *Color values*

HunterLab ColorFlex EZ (Hunter Associate Laboratory Inc., USA) was used to assess the powders' L* (brightness value), a*± (redness-greenness index), and b*± (yellowness-blueness index) values (Duangmal et al., 2008). Using the following formula and the color values of purple potato puree, the total color change (ΔE) was determined (Telis & Martínez-Navarrete, 2009). Measurements were repeated three times.

$$\Delta E = [(L^*-L_0^*)^2 + (a^*-a_0^*)^2 + (b^*-b_0^*)^2]^{1/2}$$

#### *Bulk and tapped density*

Using the mass/volume ratio, the bulk density (ρB) of about 2 g ($m_0$) of microencapsulated olive oil powder was determined by filling a 10 ml cylindrical container with no air pockets and applying any pressure (Bhandari et al., 1999). The mass to volume ratio of the powder in the cylinder following 50 taps on the bench of a 10 ml cylindrical container holding the sample was used to calculate the tapped bulk density (ρT)

(Goula & Adamopoulos, 2004). Measurements were repeated three times.

Bulk Density (ρB) (g/mL) = $m_0 / V_0$
Tapped density (ρT) (g/mL) = $m_0 / V_n$

$V_0$: Volume in the cylinder,
$V_n$: Sample volume in the same cylindrical container at tapped density

***Flowability***
The Carr Index (CI) and Hausner ratio (HR) values were used to examine the powders' viscosity characteristics. Bulk density and tapped density values were used to calculate these values (Carr, 1965).

$$CI = ((\rho T - \rho B) / \rho T) * 100$$
$$HR = (\rho T / \rho B)$$

***Wettability***
The wettability of the powder sample was examined by measuring the full wetting time of 1 g of powder sample in a 250 ml beaker filled with 100 ml of clean water at 25 °C (±1 °C) (Jinapong et al., 2008). Analyses were repeated three times.

***Water absorption capacity (WAC)***
WAC is expressed as the percentage of water absorbed per gram of sample by weighing the residue obtained after centrifuging the powders (Shafi et al., 2016). Measurements were performed with two replicates.

***Water solubility index (WSI)***
WSI was determined following the method of Asaduzzaman et al. (2013). Ten milliliters of distilled water were thoroughly combined with one gram of each sample. The mixture was centrifuged at 4,000 rpm for 30 minutes. The resulting supernatant was oven-dried at 70 ± 5°C until its weight remained constant. After cooling in the desiccator, the dried samples were weighed. The formula used to calculate WSI was as follows:

$$WSI (\%) = W_1 - W_2 \div W * 100$$

W = Dried sample weight; $W_1$ = Weight of petri dish and dried liquid; $W_2$ = Weight of empty petri dish.

***Antioxidant activity analysis***
The antioxidant activities were carried out using the approach developed by Yu et al. (2002). The antioxidant activities were assessed using their hydrogen-binding ability to trap the DPPH radical. This method involved taking 0.1 ml of appropriately diluted sample extracts in a specific concentration range and the standard substance Trolox, then adding 3.9 ml of DPPH ethanol solution ($10^{-4}$ M), mixing in a vortex, and keeping in the dark at room temperature for 2 hours until the reaction stabilized. The absorbance of the color produced by the reaction was measured at 517 nm using a spectrophotometer. A linear calibration curve was obtained with Trolox, and results were expressed as mg Trolox equivalents per 100 g samples. Analyses were repeated three times.

## Results and Discussion

In the food industry, the maximum acceptable moisture content for many dry products is between 3-4% (Klinkesorn et al., 2006). In order to ensure microbial stability in foods, the water activity value should be below 0.6 (Quek et al., 2007). The moisture content value of the powders was measured as 1.99% for the potato powders obtained by drying in lyophiliser and 2.32% for the potato powders obtained by drying in oven, and the water activity values of the powders were determined as 0.10±0.01 and 0.24±0.01 for powders (lyophiliser) and powders (oven) (Table 1).

Bulk density values of freeze-dried and hot air-dried purple potato powder samples were 0.57 g/cm³ - 0.22 g/cm³ and tapped density values were 0.69 g/cm³ - 0.31 g/cm³, respectively (Table 1). Low bulk density is an indication that the powder product is cohesive, i.e. has poor flowability. Bulk and tapped density, Carr's index and Hausner's ratio values are important evaluation criteria in the processing and storage of powdered products. The flowability properties of the powders were analyzed using

Carr's Index and Hausner's ratio values. CI and HR values are evaluated as <15 (very good), 15-20 (good), 20-35 (medium) and 35> (bad) and <1.2 (low), 1.2-1.4 (medium) and 1.4 (high) respectively (Jinapong et al., 2008).

Carr's Index values for different drying methods (freeze drying and oven drying) for purple potato powders were determined as 18.27 and 27.94; Hausner ratio values were determined as 1.22 and 1.39, respectively (Table 1**).** Cohesiveness and fluidity values were evaluated. It was found that freeze-dried purple potato powders gave better results. It was determined that its cohesion was low and its fluidity was at medium level. The obtained results show that the drying process has a statistically significant effect on the CI and HR values of the powder samples ($p$<0.05).

**Table 1.** Physical analysis of purple potato powder

| Physical properties of powders | Powder (lyophilizer) | Powder (oven) |
|---|---|---|
| Water content (%) | 1.99±0.01$^{a}$ | 2.32±0.03$^{b}$ |
| Water activity | 0.10±0.01$^{a}$ | 0.24±0.01$^{b}$ |
| ρB (g/cm$^3$) | 0.57±0.02$^{b}$ | 0.22±1.01$^{a}$ |
| ρT (g/cm$^3$) | 0.69±0.01$^{b}$ | 0.31±0.03$^{a}$ |
| CI (%) | 18.27±0.77$^{a}$ | 27.94±1.19$^{b}$ |
| HR | 1.22±0.01$^{a}$ | 1.39±0.02$^{b}$ |
| Wettability (s) | 1.85±0.06$^{a}$ | 3.70±0.1$^{b}$ |

Different letters in the same row are statistically significant
Mean±standart deviation: results are the means of three repetitions

The wettability of powder products varies depending on the surface properties of the powders, mixing, temperature, particle size, presence of amphiphilic substances, and pore structure (Sharma et al., 2012). Wettability in powdered food products is one of the main determinants of product performance and end-use quality. The lower wettability values can be considered an important parameter in terms of product quality. The wettability values of freeze-dried potato powder were found to be lower compared to hot air-dried potato powder. (Table 1).

Water absorption capacity is affected by factors such as protein concentration, pH, ionic strength, temperature, presence of polysaccharides, lipids, salts, other components, amount and duration of heat treatment, storage conditions as well as protein matrix (Chavan et al., 2001) In terms of functional properties, water absorption capacity is also of great importance, especially in instant foods, instant mixes and some agricultural applications (Goude et al., 2023). The water absorption capacity and water solubility index were shown in Table 2. According to the results, the water absorption capacity of lyophilizer-dried powder samples was higher than that of oven-dried powder samples. These values were 5.03 and 4.90 % for lyophilizer and oven dried powder samples, respectively.

The water solubility index is affected by parameters such as the initial composition of the dried raw material, the carrier agents it contains, the drying method applied, temperature, and feed rate (Kha et al., 2011). According to the water solubility capacity values obtained, the values of the powder samples dried in the lyophilizer and in the oven were determined as 3.16 and 3.03, respectively. According to these results, it can be stated that a more compact powder is obtained with the oven drying method and thus the solutes pass into the aqueous phase more slowly (Table 2). According to the obtained results, it has been determined that the drying method is statistically effective on water absorption and solubility capacity ($p$<0.05).

**Table 2.** Water absorption capacity and water solubility index

| | Powder (lyophilizer) | Powder (oven) |
|---|---|---|
| **WAC (%)** | 5.03±0.02$^{b}$ | 4.90±0.02$^{a}$ |
| **WSI (%)** | 3.16±0.01$^{b}$ | 3.03±0.03$^{a}$ |

Different letters in the same row are statistically significant
Mean±standart deviation: results are the means of three repetitions as percent

The $L$* value (brightness) is $a$* scale that measures the brightness of the product and the numerical value decreases as the product color darkens. The decrease in $a$* and $b$* values may be due to the degradation of chlorophyll as well as non-enzymatic reactions (Maskan, 2001). The $L$ value of the powder samples obtained by freezing and hot air drying was found to be brighter and whiter than the puree. *L* and *a** values similar increase was observed in the freeze-dried kiwi purees (Maskan, 2001). Alibas (2007) stated in his study that he dried pumpkin using microwave, hot air, and microwave-hot air combined methods, and noted that the *L*, *a**, and *b** values decreased in all three drying methods. As seen in Table 3, the *a** and *b** values of the powder samples obtained by both drying methods showed *a** and *b** decrease compared to the mash. The lowest values were determined in the powder samples dried in the oven. Statistically, a significant difference was determined in the change in *L* and *a** values of pureed and dried $p<0.05$ samples. Similarly, the fresh *L* values of fruits dried using different drying methods were lower than those of dried samples. The drying process increases brightness (Zhang et al., 2023; Akcicek et al., 2023).

**Table 3.** *L*, *a**, *b** values of samples

| Color parameter | Puree | Powder lyophilizer | Powder (oven) |
|---|---|---|---|
| *L* | 39.36±0.65[a] | 58.11±0.24[b] | 59.57±0.08[c] |
| *a** | 13.61±0.26[c] | 9.34±0.87[b] | 7.58±0.03[a] |
| *b** | 11.95±0.41[a] | 7.16±0.80[b] | 6.32±0.04[b] |

Different letters in the same row are statistically significant
Mean±standart deviation: results are the means of three repetitions as color values

The results of the total color change (ΔE) showed that oven drying had a higher and freeze drying had a lower effect on the color change, indicating that freeze drying had less effect on the color change (Table 4).

**Table 4.** Total color change (ΔE*) of purple potato powders

| | Powder (lyophilizer) | Powder (oven) |
|---|---|---|
| **ΔE** | 19.82±0.56[a] | 21.83±0.73[b] |

Different letters in the same row are statistically significant

Antioxidant activity values of the samples are given in Table 5. The antioxidant activity values of lyophilizer and oven dried purple potato powders were determined by DPPH method. The antioxidant activities of mash and powder samples were calculated as mg trolox/100g dry matter. As a result of the drying process, a statistically significant difference was determined between the antioxidant values of purple potato puree and powder samples. It was determined that the antioxidant activity value decreased with the drying process and the antioxidant amount of the powder samples obtained by oven drying was less. It was determined that freeze drying process preserved the antioxidant amount of purple mashed potatoes more than oven drying. The data obtained as a result of the effects of different drying treatments on the antioxidant activity of purple sweet potato are in agreement with the results of previous studies (Inchuen et al., 2008; Sultana et al., 2012; Wang et al., 2019).

**Table 5**. Antioksidant activity of samples

| Samples | DPPH (mg trolox/100g DM) |
|---|---|
| **Puree** | 553.35±4.41[c] |
| **Powder (lyophilizer)** | 425.56±2.18[b] |
| **Powder (oven)** | 307.05±3.25[a] |

Different letters in the same column are statistically significant
Mean±standart deviation: results are the means of two repetitions as mg trolox/100g DM

## Conclusion

The physical moisture content of purple potato powders obtained by freeze and oven drying is below 3-4% and the water activity values are below 0.25. These results show that it has food stability in terms of oxidation, enzymatic browning and microbial growth. The Carr Index and Hausner Ratio results determined that the freeze-dried samples exhibited better flowability and lower cohesiveness than the powder samples obtained by oven drying. Total colour change was calculated to be less in freeze-dried powder samples compared to purple mashed potato. This indicates that freeze drying preserves the colour stability. The water retention and water absorption capacity results determined that the water solubility index and water absorption capacity were lower as a result of obtaining a more compact powder with the oven drying method compared to the freeze drying method. The highest value of antioxidant result obtsined in puree and freeze drying preserved the antioxidant value of purple mashed potato more than oven drying. As a result, physical properties and antioxidant capacity values of purple potato were found to be better with freeze drying method.

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