



Effects of Drying Methods and Onion Bulb Variety on Physicochemical and Functional Properties of Onion Powder

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Authors' contributions

This work was carried out in collaboration among all authors. Author BSBB designed the study and wrote the protocol. Author ACAK wrote the first draft of the manuscript. Authors ACAK, JAN, MSHA managed the analyses of the study. Authors BSBB and ACAK performed the statistical analysis. Authors BSBB and YRS managed the literature searches. Authors ACAK, BSBB and YRS revised the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Onion (*Allium cepa* L.) is a rich source of constituents that are beneficial to human health. However, the short shelf life of these vegetables are a major cause of postharvest losses during peak harvesting season. Drying is one of the most convenient technologies for shelf stable food products production. This study is aimed at assessing the effects of three drying methods (industrial oven, electric dryer and sun drying) on physicochemical (moisture content, ash content, pH, titratable acidity, total polyphenol contents) and functional properties (water solubility and particle sizes) of onion powders of two onion varieties (white and violet of galmi). From the results obtained, physicochemical and functional components are affected significantly ($P < 0.05$) by drying

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process but not titratable acidity (to the order of 36 mEq/100g DM). In addition, the moisture content of onion powders were below 13.66±0.115, 14.73±0.115, 14.60±0.305 g/100g WM for industrial oven, electric dryer and sun drying respectively with pH between 3.29 and 5.16. In addition, these powders showed a small particle size (under 400 µm) and high solubility as 93.33±2.3, 72±0.5, 62.66±2.3 g/100 g DM for Electric dryer (ED), Industrial oven (IO) and Sun drying (SD) respectively. Furthermore, polyphenol content was almost different in all the different drying process with values between 721.32 to 962.26 mg GAE/100g DM. Moreover, all properties were varied significantly ($P<0.05$) between white and violet of galmi powders. The preferred drying method and onion variety were industrial oven and violet of galmi. Finally, these results could be a valorization way to promote an industrialization of onion powders.

Keywords: Onion; drying methods; variety vegetable; functional ingredients; total polyphenols.

1. INTRODUCTION

The onion is a vegetable belonging to the superorder of *Liliiflorae*, to the order of *Asparagales*, to the family of *Alliaceae*, to the genus *Allium* and to the species *Allium cepa* [1]. Although most frequently known as a biennial or a perennial plant, it is usually treated as an annual plant and is harvested in its first growing season [2]. Moreover, onion plant shows a fan of hollow bluish green leaves, which base swells to give a more or less important bulb [3]. Based on the bulb color, onion are classified into white, yellow, red, and violet varieties [4].

In addition, onion is one of the most widely consumed vegetables and the oldest cultivated crops in world [5]. Its global production was estimated at about 97.86 million metric tons in 2018 [6]. Furthermore, it is rich source of β -carotene, vitamin C, calcium and iron [7]. Likewise, it demonstrated a good aroma, flavor, and pungency taste making it to be used as functional food ingredients. Besides, many studies reported its preventive and curative effects for eye inflammation, respiratory problem, fight against infections due to its sulfur compounds and its anti atherogenic effects [8]. Ogzur et al. [9] also suggested its tumor-inhibitory properties. Moreover, onion is also found as a rich source of polyphenols known for their health promoting benefits and anti-disease factors due to their high antioxidant and antiradical properties in reducing the risk of radical-mediated pathogenesis such as carcinogenesis, atherosclerosis, diabetes, Alzheimer, cataracts, and age-related functional decline [10-11].

However, onion is a perishable product due to its high water content around 87% [12]. Thus, preservation methods, which extend shelf life of onion bulbs, are needed in order to make onion

products available in all seasons and in any localities as well. In this context, powdered onion through drying is one of the main processing routes [13]. In fact, powder enable to store food while reducing volume, weight and packaging, and also ease preservation, handling, and transportation [14]. In addition, drying is a well-studied unit operation in process engineering which reduce moisture content in the food matrix up to a level safer for storage, for transportation, for avoiding microbial multiplication, for slowing down/inactivating microbial activity [15]. Dried onion products are sometimes preferred than fresh onion bulbs because of its simplicity to be used and its great shelf stability [16].

However, food materials drying process is extremely complex since they simultaneously involve heat, mass and momentum transfer mechanisms coupled with physical, chemical, structural transformation of the product [17]. Therefore, several drying methods were developed and are dependent on fruits and vegetables to be dried. Sangwan et al. [7] dried onion using shade, solar, oven and microwave. They reported that the resulted onion powders showed a good nutritional profile. To add, Santana et al. [18] revealed that parameters of physical analysis of *ilex guayusa leaves* were not affected by air-drying (AD), convection oven (CO) and solar drying (SOD). In the same way, Sangwan et al. [7] reported that polyphenol content was almost similar in all the different dried onion powders (shade, solar, oven and microwave). On the other hand, drying African eggplant using solar, oven, vacuum drying and freeze-drying, Mbondo et al. [19] showed that freeze-drying was the most effective in retaining the highest bioactive compounds. Solar-drying affected total phenolic content, antioxidant capacity, and beta-carotene contents followed by oven, vacuum, and freeze. In sum up, there is no standard drying method. The choice of drying

method for a product depend on the raw material, the desired characteristics of dried product, the operating conditions, and process cost [20]. However, Matazu and Haroun [21] reported that sun- and oven-drying are the most popular methods of drying. Moreover, sun drying preserves the colour of the product and its translucent appearance, but it is a time-consuming process, weather depended, labour demanded and it is greatly exposed to possible environmental contamination [22]. Besides, oven-drying is considered as a cost effective method although some compounds can be destroyed due to high temperature used [23].

In addition, biochemical compositions resulting in beneficial properties of fruits and legumes were also variety dependence [19,24]. According to Jaffery et al. [25], composition and quantity of phenolic compounds significantly vary within family due to genetic pattern, cultivar and harvest conditions. Furthermore, Seifu et al. [24] showed variability in physical, chemical, and sensory properties of onion powder were significantly different between onion varieties. Moreover, Djiogue et al. [26] also demonstrated nutritional and functional properties of onion powder differed between three varieties (Violet, Goudami and White of Galmi). Likewise Markowski et al. [27] reported that color and water absorption after drying were significantly affected by carrot varieties (Kazan, Maxima, Nandor, Nektarina, Simba and Tito).

In the context, this study aimed to evaluate the effects of three drying methods (industrial oven, electric dryer and sun drying), physicochemical (moisture content, ash content, pH, titratable acidity, total polyphenol contents) and functional properties (water solubility and particle sizes) of onion powders of two onion varieties (white and violet of galmi).

2. MATERIALS AND METHODS

2.1 Materials

Two different varieties of onion (violet of galmi and white of galmi) were collected from five local market in Yamoussoukro, Côte d'Ivoire and transported to the laboratory. These onions bulbs sorted to remove defective bulbs and others external impurities and then were weighed. Thus, 4 kg and 1 kg violet of galmi and white of galmi respectively were obtained. They were then peeled to remove the skin and washed with tap water. Finally, they were wiped with paper towel

and stored at laboratory under temperature at 22°C for about 5 min before the following processing step.

2.2 Drying and Onion Powdering Process

2.2.1 Powder preparation

The washed onions were then sliced at approximately 10.0 ± 0.5 mm thickness with a sharp stainless steel knife in the direction perpendicular to the vertical axis. These slices were weighed and divided into five groups of 1000 g based on variety (four group for violet of galmi and one for white of galmi). All groups were then dried using different dryers as indicated in section 2.2.2 and stored at ambient temperature for 5 min and then milled using a domestic electric grinder (Blender-STPE-1220, China) for 10 min. Finally, the powders were packaged in a high density polyethylene bag and stored in a hermetically sealed paneled jar at ambient temperature until they were required for further analyses.

2.2.2 Evaluation of drying methods effects

The effect of the drying methods was assessed by using three drying methods such industrial oven (IO) and electric dryer (ED) and traditional sun-drying. IO and ED drying were performed as previously described by Bamba et al. [13]. Briefly, a sliced onion (1000 g of violet of galmi onion) were evenly distributed in a thin layer onto the stainless steel trays (0.5 x0.4 m). The tray were then placed into an IO (YCD-3-3D, China) or ED (Electric hot air food dryer, 020-84855138, China) and then dried at 70°C for 8 hours. On the other hand, sun-drying used Bamba et al. [28] method that consisted to pour the sliced onion on a clean tablecloth laid out on a table at about 1.5 m from the ground and then placed it under the sun for 11 days at the rate of 10 h per day. The air speed was 2 m/s at 32.5 ± 5 °C under 71% relative humidity. Each test was carried out in triplicate.

2.2.3 Evaluation of variety effects

Two batches of 1000 g Galmi violet and white Galmi violet were each used to assess the effect of the onion variety on the properties of the resulting powder. Each of these groups were dried as previously described in section 2.2.2 using an industrial oven. Each test was done in triplicate.

2.3 Determination of Physicochemical Properties

2.3.1 Moisture content

The moisture content of onion powder was determined according to the method described by AOAC [29] with some modifications and then calculated as percent of loss in weight using Eq. 1:

$$MC = \frac{M_1 - M_2}{M_1 - M_0} \times 100 \quad \text{Eq. 1}$$

Where MC is the wet basis moisture content (g/100g), M_1 is the initial weight of powder and dish (g), M_0 is the initial weight of dish (g), M_2 is the equilibrium weight of powder and dish (g). Each result is expressed as the means of three tests.

2.3.2 Ash content

Ash content was measured according to the method described by AOAC [29] with some modifications. About 5g of onion powders were incinerated at 550°C into muffle furnace (Heraeus electronic, France) for 4 h. Ash content was calculated using the Eq. 2:

$$AC = \frac{M_3 - M_0}{M} \times 100 \quad \text{Eq. 2}$$

Where M_0 , M_3 and M were the initial weight of the beakers, the weight of beakers containing the ash and the weight of the dry matter of the test sample respectively. The result was expressed as an average of three repetitions.

2.3.3 pH and titrable acidity (TA)

The pH value was determined using Hanna pH-meter (HI991001 model, Germany) according to AOAC [29] official method with some modifications. A sample of fresh onion slice paste or onion powders (5 g) were dissolved in 50 mL distilled water for 20 min under magnetic stirring. The titratable acidity was determined by titrating according to method described by Bamba et al. [13]. TA was calculated using the Eq. 3 below:

$$TA = \frac{V_{\text{NaOH}} \times N_{\text{NaOH}}}{W} \times 1000 \quad \text{Eq. 3}$$

Where W is the weight of the dry matter of the test sample (g); V_{NaOH} is the volume of NaOH poured (mL); N_{NaOH} is the NaOH Normality (0.1 N). Each experiment was done in triplicate.

2.3.4 Total polyphenol content (TPC)

Total phenolic content was analyzed spectrophotometrically (JASCO Model V-530, Japan) at 760 nm using the Folin-Ciocalteu colorimetric method according to a method described by Wood et al. [30] with some modifications. Briefly, phenolic compound was extracted by diluting 5 g onion powders into 100 mL of ethanol/water solution (80:20 v/v) in a beaker wrapped with an aluminum foil. The mixture was incubated for 24 hr under magnetic stirring at room temperature and then filtered under vacuum. After adding 30 μL of filtered extract to 2.5 mL of Folin-Ciocalteu reagent (1/10), the mixture was carefully stirred and kept in the dark at room temperature. After 2 min, 2 mL of Na_2CO_3 solution (75 g/L) was added following by carefully stirring. The mixture was left to react at 50°C for 15 min in a water bath before reading the absorbance at 760 nm using a spectrophotometer (JASCO Model V-530, Japan) against distilled water treated in the same conditions. The total phenolic content was determined using a standard curve prepared with gallic acid (0; 0.2; 0.2; 0.4; 0.6; 0.8; 1 and 1.2 g/l; $R^2 = 0.99$) and the results were then expressed as mg of gallic acid equivalents per 100g dry matter (mg GAE/100g dry matter). Each experiment was carried out in triplicate.

2.4 Determination of Functional Properties

2.4.1 Water solubility test (WSI)

The solubility was determined according to the method reported by Cano-Chauca et al. [31] with some modifications. For that, 1 g powder was suspended in 100 mL distilled water under magnetic stirring for 5 min. Then, the solution was centrifuged at 3000 \times g for 15 min using a HETTICH model EBA III centrifuge (Germany) and a 25 ml supernatant was transferred to a 50 mL beaker and dried at 105 °C for 24 h. Water solubility (WSI) expressed as an average of three tests, was calculated by weight difference using equation below:

$$WSI = \frac{D_w}{0.25 \times W_s} \times 100 \quad \text{Eq. 4}$$

Where D_w denotes to dry weight of 25 mL (g) and W_s , the weight of the dry matter of test sample (g). The result was expressed as an average of three repetitions.

2.4.2 Granulometric analysis

The particle sizes were determined according to the sieving method described by Bamba et al. [13]. The sampled onion powder (10g) were poured onto the upper sieve of a series mounted vertically in decreasing order of meshes (1200, 800, 400, 200 μm) and the lid closed. The whole was then securely placed on a mechanical stirrer (RETSCH brand model AS200, Germany) and agitated for 3 min at 60 amplitudes. The fractional rejection frequency of powder on each sieve was determined as the ratio of the fraction obtained to the initial weight of powder. The experiment were done in triplicate.

2.5 Statistical Analysis

All the results were reported as mean values of three repetitions with their standard deviation (SD). One-way ANOVA or student test was used for comparisons among all groups as appropriate. Statistical differences among the means of all experiments content were determined with Newman and Keuls post hoc tests ($\alpha = 5\%$; $p < 0.05$). Statistical analyses were performed using STATISTICA version 10.0 software (StatSoft, Tibco Software, Paris, France).

3. RESULTS AND DISCUSSION

3.1 Effects of Drying Methods and Variety of Onion on Physicochemical Properties of Onion Powders

3.1.1 Moisture content of onion powders

Moisture content related to the water remained inside the cell, once the extracellular water was removed by drying. It indicates the drying efficiency and ability of food deterioration by microorganisms and biotransformation of secondary metabolites [18]. Then, it is key indicator of food stability. In addition, Table 1

shows the moisture content of onion powders resulted from industrial oven (IO), electric dryer (ED) and sun drying (SD). It can be noticed that moisture content differed significantly ($p < 0.05$) between IO, ED and SD. Moisture content of onion powder was found to be higher when sun drying (SD) was applied, followed by Electric drying (ED) and then industrial oven (IO). This observation may be due to convective drying of onion slices in ED. Indeed, the heated air (of low relative humidity) meets the surface of the wet material that transfers heat into the solid primarily by conduction. The liquid migrates then onto the material surface and transports away by air convection in this method [32]. However, Sangwan et al. [7] reported no significant difference in moisture content of onion powder dried by using four different drying methods viz. shade, solar, oven and microwave. They indicated lower value of moisture content in onion powder (2.62 - 2.82%). These results were slightly lower than those reported in this study, mainly due to the difference in methods, drying temperature and time. Besides, the highest moisture content was found for SD due to the fluctuating temperature during the drying period. SD is extremely time-consuming, weather dependent and has the problem of contamination, infestation and microbial attack [33]. This method is widely practiced in tropical countries.

The moisture content of fresh onion was previously found to be 86.34 ± 0.95 g/100g WM [13]. Then, from the results presented in Table 1, it can be seen that drying considerably reduced the ratio of moisture (at least 80%) whatever the drying methods. Indeed, mass losses were 84.12, 82.87 and 81.88% for Industrial oven (IO), Electric dryer (ED) and Sun drying (SD) respectively. This performance may due to the difference of temperature and water partial pressure established spontaneously between the foods and a hot air during drying [34].

Table 1. Physicochemical properties on onion powders

Onion powders	Moisture content (%)	Ash content (g/100g DM)	pH	Titrateable acidity (mEq/100g DM)	
White of galmi	Industrial oven	13.66 ± 0.15^b	1.33 ± 0.23^c	4.33 ± 0.06^b	35.33 ± 0.58^a
	Electric dryer	14.73 ± 0.12^a	2.26 ± 0.12^b	5.16 ± 0.05^a	36.50 ± 0.71^a
	Sun drying	15.60 ± 0.31^a	2.86 ± 0.31^a	3.29 ± 0.06^c	36.33 ± 1.15^a
White of galmi	Industrial oven	16.33 ± 0.31^a	2.60 ± 0.35^b	3.94 ± 0.00^b	33.00 ± 1.00^b

Values with the same superscript along the column are not significantly different ($p > 0.05$)

The effects of variety on moisture content of onion powder can be seen in Table 1. The moisture content values were significant difference ($p < 0.05$) between white ($16.33 \pm 0.31\%$) and violet of galmi ($13.66 \pm 0.15\%$ WM). This result is in agreement with those in Armand et al. [35] who reported that moisture content of White of galmi, Goudami and Violet of galmi varieties decreased considerably of 90.55, 78.71 and 72.50% respectively during solar and electric drying process. To add, moisture content in this study are above those reported by Seifu et al. [24] in their research on effect of variety and drying temperature on physicochemical quality, functional property, and sensory acceptability of dried onion powder. These data were 6.6%, 5.3%, and 4.9% for Sweet carolin, Bombay red, and Qellafo onion powder respectively. The change in moisture content could be due to difference in variety, in drying method and conditions such hold time and thickness of slices.

3.1.2 Effects of drying methods and variety on ash content

Table 1 presents the results of ash content as a function of drying methods. It can be observed that ash content significantly differed ($p < 0.05$) based on the drying methods. The industrial drying method showed the lowest ash value (1.33 ± 0.23 g/100g DM), followed by electric drying (2.26 ± 0.12 g/100g DM), and then sun drying (2.86 ± 0.31 g/100g DM). In addition, ash content of fresh onion was found to be 3.33 g/100g DM which was slightly higher than the processed onion ash content indicating that drying reduced ash content. The decrease in ash content could be due to water and volatiles vaporization, organic substances burning in the presence of oxygen in air, and minerals conversion to oxides, sulfates, phosphates, chlorides, and silicates during the ashing process [36]. In addition, the lowest ash content from IO and ED could be attributed to high volatilization of alkali metal in the form of inorganic salts caused by these methods. According to Shen et al. [37], the amount of elements lost through volatilization depends on the heating temperature, the main form of the elements in the samples and the chemical environment during incineration. Moreover, Sangwan et al. [7] also reported high ash value (from 4.23 to 4.46%) on onion powders prepared using shade, solar, oven and microwave drying methods. The difference with this study would be related to vegetable

varieties and drying methods used by the authors.

As far as concern the effect of variety on ash content, it can be seen in Table 1 that ash content significantly differed between varieties ($p < 0.05$). White of galmi powder showed higher ash content (2.60 g/100 g DM) compared to violet of galmi powder (1.33 g/100 g DM). This observation can be attributed to the growing conditions [38], mineral nutrition and environment [39].

3.1.3 Effects of drying methods and variety on pH and titratable acidity (TA)

The pH is a biological and chemical quality indicator which gives an idea on product quality. As shown in Table 1, pH values of onion powder varied significantly ($p < 0.05$) between drying methods and varieties as well. Armand et al. [35] recorded similar observations. In addition, pH value of fresh onions was 5.26 ± 0.21 in this study which decreased when Industrial oven (4.33 ± 0.06), electric dryer (5.16 ± 0.05) and sun drying (3.29 ± 0.06) were applied. Moreover, the lowest pH value was observed with sun drying. However, Armand et al. [35] reported high pH values (6.61) when studying the effect of solar and electric drying on physicochemical and biochemical composition of three varieties of onion (White of galmi, Violet of galmi and Goudami). The different could be attributed to drying temperatures and times, origin of onion and drying methods. Thus, the low pH value observed from IO, ID and SD in this study could positively affected the powder conservation because acidification enhanced food preservation [40].

In addition, titratable acidity (TA) which expressed the total acid concentration within a food, seems to be the better predictor of acid's impact on flavor than pH [41]. The TA value of the fresh onion was 14.86 mEq/100g DM [13]. As shown in Table 1, drying methods did not significantly affected TA values of powdered onion. Contracted results were reported by Seifu et al. [24] who found an increased in TA value after drying. Authors demonstrated that the increase in TA resulted from the conversion of sugar into organic acids during dry. However, TA data indicated that onion powders in this study are highly acidic.

As concerned the effect of variety on onion powder pH value, it come out from Table 1 that pH values were under 4.5 and significantly

differed between white (3.94) and violet (4.32) of galmi. Furthermore, pH values were decreased after drying. Therefore, this acidic pH score could decelerate or even prevent the growth of pathogenic food microorganisms except molds and yeasts [24]. On the other hand, titratable acidity of these two varieties were significantly different ($p < 0.05$). Then, white of galmi powder showed the lowest value. Seifu et al. [24] when drying Bombay red onion (0.284%), Qellafo (0.318%) and Sweet carolin (0.260%) reported this similar observation. In addition, these authors also observed that TA increased while pH decreased after drying regardless of the variety. Therefore, pH and TA are found to be variety dependent.

3.1.4 Effects of drying methods and variety on total polyphenol contents

Polyphenols are secondary plant metabolites known for their health benefit interests in several chronic diseases prevention such as cardiovascular diseases, certain cancers or type 2 diabetes [42]. Total polyphenol content (TPC) in fresh onion was 1200 mg GAE/100g DM (Data not shown) [13]. Fig. 1 presents the variability of TPC in resulted powder from three drying methods. It is shown in this study a decrease of TPC on all drying methods (Fig. 1A). It can be observed that TPC values differed significantly from one method to another. However, IO showed the highest TPC value (962.26 ± 1.56 mg GAE/100g DM), followed by SD (835.23 ± 1.22 mg GAE/100g DM) and the lowest value was found for ED (721.32 ± 2.32 mg GAE/100g DM). In fact, the decrease in TPC from the fresh onion to the processed products could be attributed to activation of oxidative enzymes (polyphenoloxidase and peroxidase) during processing, to the binding of phenolic compounds to proteins and to thermal degradation [43-44]. These results contradicted that of Shokry [45] who mentioned TPC increasing in dried red beet (*Beta vulgaris*) and very low values (34.85 - 417.6 mg GAE/100g) by oven, sun and microwave drying. The increase in TPC in red beet could be mainly attributed to the presence of the bound form of phenolic compounds rather than the free form, which are not affected by heat treatment due to their association with the cell wall of vegetables [46].

Furthermore, the lowest values of TPC from ED might be explained by its severe drying mechanism resulted from radiation.

Nevertheless, TPC value in this study were very high regardless the method employed.

Fig. 1B also shows the effect of onion variety on polyphenols contents of powder resulted from Industrial drying process. As shown, TPC values of violet and white of galmi powder were significantly different ($p < 0.05$) and were 960.24 ± 0.89 and 636.36 ± 0.76 mg GAE/100g DM, respectively. For Tiwari and Cummins [47], the polyphenol content in fruits and vegetables may vary with different pre-and post-harvest processing operations.

3.2 Effects of Drying Methods and Variety of Onion on Functional Properties of Onion Powders

3.2.1 Effects of drying methods and variety on onion powders particles sizes

Sieving, as a method for size classification, is widely used for characterizing the range of grain size present in powder. In this technique, the powder is separated into several fractions of particles having the same size [48]. Particle size distribution of onion powder resulted from three drying process were depicted in Fig. 2A. It can be seen that the three drying methods resulted in powders of which 80-95% have particle sizes less than or equal to 200 μm . In addition, they showed a significant difference in 200 μm fraction proportion. Indeed, ED led to higher proportion (91%), followed by IO (86%) and SD (79%). This small particle size found in this study could be attributed to the low moisture contents favoring a good milling of the slices. In addition, the highest fraction proportion of ED and ID compared to SD might be explained by the highest temperature and its control ability in these process leading to low moisture content whereas in SD, temperature is low and could not be control resulting in high moisture content [13].

In addition, as shown previously concerning drying process, variety resulted in a powder with particle size less than 200 μm and fraction proportion differed significantly ($p < 0.05$) regardless the mesh size (Fig. 2B). The fraction proportion (violet/white) were 92%, 5%, 2% and 1% on 200, 400, 800 and 1200 μm respectively. This observation could be due to highest moisture content in white of galmi powders (16.33%).

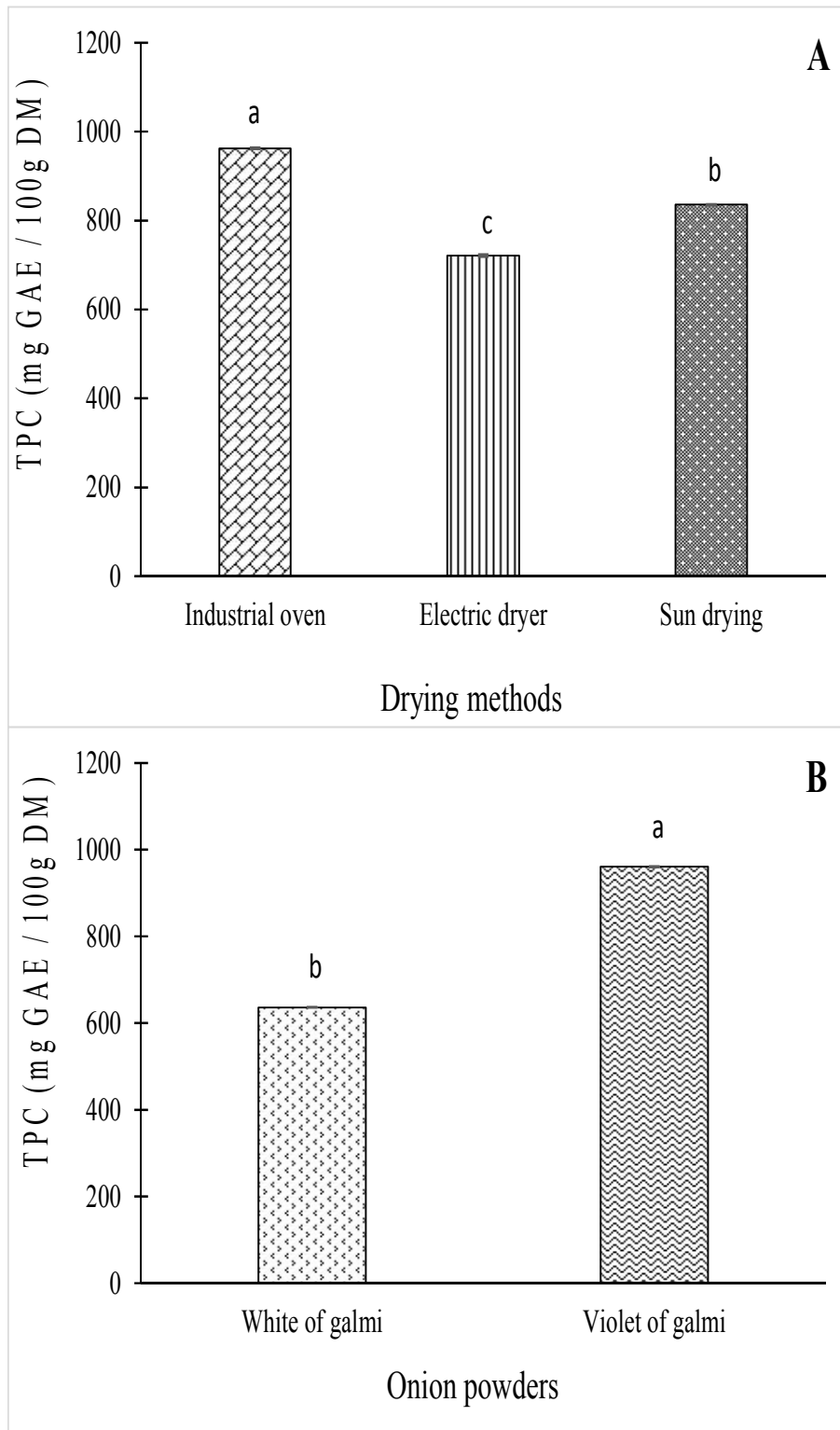


Fig. 1. Effects of drying methods and onion variety on total polyphenols content of onion powder

Different superscript letters mean significant difference ($p < 0.05$)

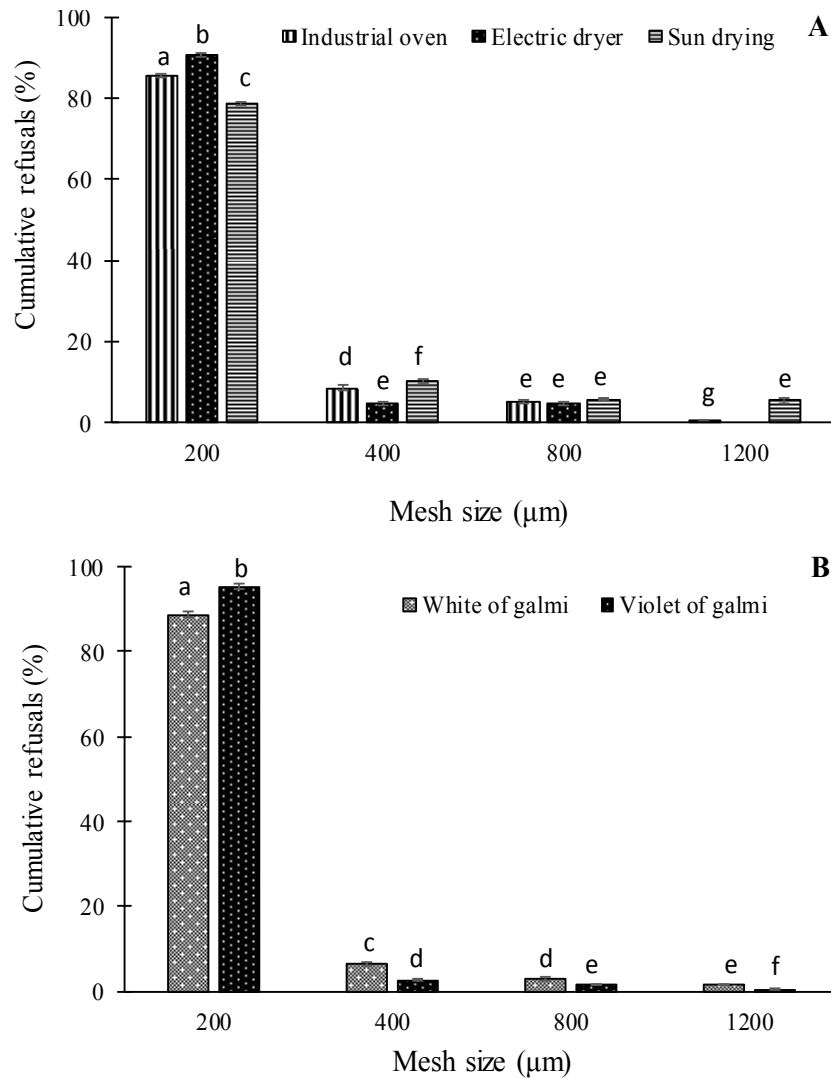


Fig. 2. Effects of drying methods on particle sizes of onion powders
 Different superscript letters mean significant difference ($p < 0.05$)

3.2.2 Effects of drying methods and variety on water solubility

Fig. 3A shows that drying methods significantly affected water solubility ($p < 0.05$). Indeed, water solubility of onion powder obtained from industrial oven (IO), electric dryer (ED) and sun drying (SD) was 72 ± 1.8 , 93.33 ± 2.32 and 62.66 ± 2.31 g/100g DM respectively. It can be observed that Electric dryer showed the highest water solubility. This parameter play a key role in food preparation process because it measured the ability of the powders dissolve and form a stable suspension [49]. Thus, all powders obtained in this study was very soluble. This result might be explained by the low particle

sizes reported in the study. Indeed, particle size is one of the important indicators of the solubility of a product, the lower the particle sizes, the higher the contact surface and the higher the solubility could be.

However, no significant difference ($p < 0.05$) was observed in water solubility between the two onion varieties used in this study (Fig. 3B). The water solubility was shown to be around 71 g/100g DM regardless the variety. Then, higher water solubility could be attributed to a higher degree of macromolecular disorganization of the material as affected by drying process and condition [50].

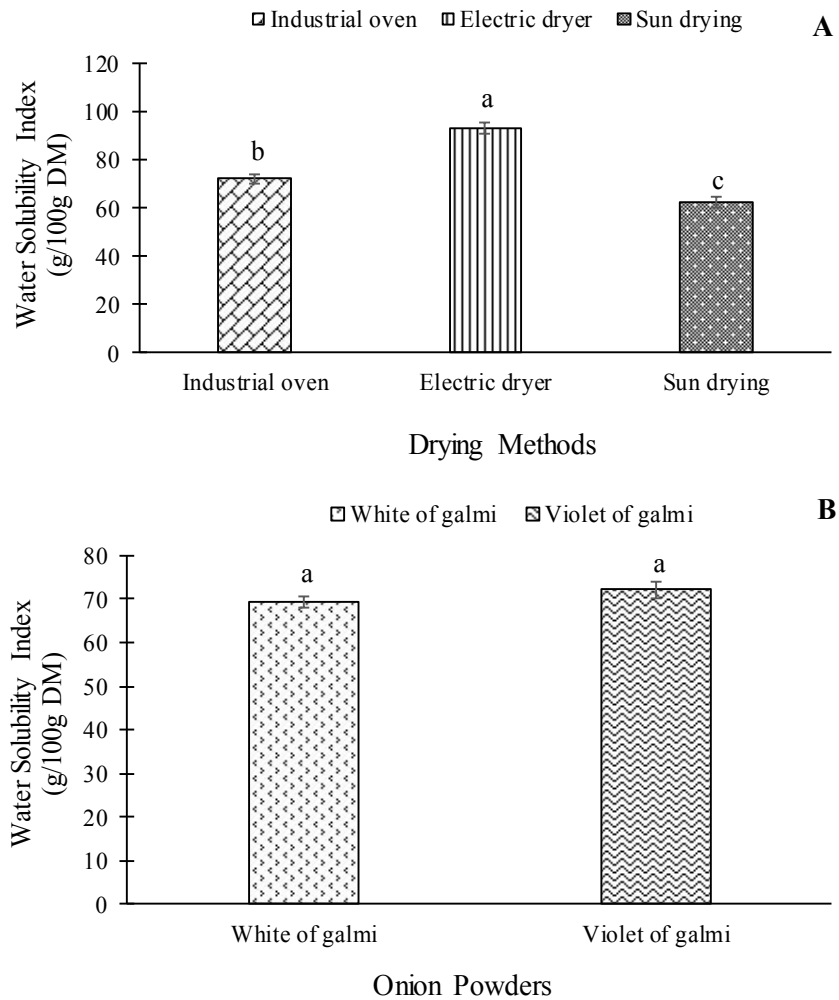


Fig. 3. Effects of drying methods and onion variety on water solubility of onion powders
Different superscript letters mean significant difference (p < 0.05)

4. CONCLUSION

This work aimed to evaluate the effects of drying methods and variety on physicochemical and functional properties on onion powders. Drying process were found to significantly affect all parameters except titratable acidity. The moisture, ash, pH and total polyphenols content decreased after drying in all process while titratable acidity and water solubility increased. In addition, the onion powders from an industrial oven had the lowest moisture content and the highest total polyphenols contents. However, electric dryer demonstrated the highest water solubility and particle sizes distribution of onion powders. Furthermore, physicochemical and functional properties of violet of galmi powder compared to that of white of galmi were

significant different .Therefore, violet of galmi and industrial oven are respectively recommended as a suitable onion variety and drying method in this study.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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