

## Evaluation of Micronutrient Composition, Phytochemical Properties and Acceptability of Selected Nigerian Culinary Products made with Onion Powder (*Allium cepa. L*)

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### Abstract

Nigerian culinary products made with red and white onion powder (*Allium Cepa. L*) was investigated for phytochemical, micronutrient, and sensory acceptability. Bean pudding, boiled meat, vegetable stew, pizza, and fried egg was prepared with 20 and 40g of the powders with fresh red and white onion as controls. Proximate (moisture, protein, fat, carbohydrate, ash) phytochemical (total phenol, flavonoid, ascorbic acid,  $\beta$ - carotene), mineral (zinc, calcium, iron, copper) were determined using standard procedures. Proximate composition indicated moisture (82.99-82.42), protein (6.34-6.53), fat (0.65-0.72%), crude fibre (3.95-4.20), ash (1.42 -1.92) and carbohydrate (4.05- 4.07% in fresh red and white onion. Values from 6.19-9.54 % total sugar, 72.67- 88.43  $\mu\text{mol/g}$  pyruvate and 53.12-60.25 kcal / 100gm total energy were recorded for fresh and dried onion powder. Dried red onion powder recorded higher total phenol (70.64, 46.93 GAE/g) total flavonoids (133.25, 94.91 mgQE/g) ascorbic acid (21.94, 9.09 mg/100g) and carotene (0.26, 0.19 mg/100g) compared to the white dried onion powder. Macro elements in the fresh onion was in the order  $\text{Ca} > \text{K} > \text{Fe}$ , and trace elements  $\text{Zn} > \text{Cu}$  was predominant in the fresh white onion. Bean pudding, boiled meat and pizza prepared with 100g fresh red and white onion was rated higher in overall acceptability. Scrambled egg prepared with 40g dried red and white onion powder showed higher value in overall acceptability. No significant ( $p > 0.05$ ) difference was observed in colour, taste, flavor and pungency. The colour of onion powder was not pronounced in the overall acceptability of the culinary products in this study.

**Keywords:** Micronutrient, Nigerian Culinary, Onion Powder, Phytochemicals, Sensory Acceptability.

### Introduction

The onion (*Allium cepa L.*) is one of the most widely grown commercial bulbous vegetable and a common cash crop grown all over the world (Pareek et al., 2017, Novak, 2018). Onions are divided into white and red varieties based on their colour and is well known for its distinct flavour (Cheng et al., 2025). Several functional compounds such as anthocyanin, quercetin, and alkenyl cysteine sulfoxides, contribute to onion's health benefits (Teshika et al., 2019). It also has a high concentration of carotene, vitamin C, calcium, and iron, as

well as a pleasant aroma, odour, and pungency, making it an excellent nutritious and functional food ingredient. Due to its sulfur compounds, onion has a protective and curative effect for eye inflammation, respiratory problems as well as antimicrobial activities (Tang, et al., 2026). However, due of its high-water content (about 87%), onion is a perishable commodity (Endalew et al., 2014). The bulb is the most widely used part of the plant, and it is used as a food ingredient to add flavour and fragrance to a variety of dishes (Ajiboye et al., 2022; Sachan *et al.*, 2018). In tropical countries, proper onion bulb handling has become a serious concern. In Nigeria, onion production is reduced by about 60% due to a short shelf life and high post-harvest losses (Bulama et al., 2024). Inadequate onion transportation from the Northern part of Nigeria results in significant losses in onion production. Growers and even marketers face financial constraints as a result of postharvest losses. The most popular preservation approach is drying, a combined heat and mass transfer process that has the ability to reduce post-harvest losses (Galib et al., 2022). This method of preserving fruits, vegetables, and spices is regarded to be the most effective and profitable to prolong shelf life and improve food stability (Zzaman et al., 2021). Onion powder production ensures that onions are available all year round and during off-season. Onion powder reduces the rate of degradation and minimizes post-harvest losses that occur during onion bulb handling. Converting onion produce into more shelf stable differentiated value-added produce helps to minimize losses and promote food security (Engurat et al., 2024). Due to eye irritation that fresh onions cause during slicing in the preparation of dishes, some Nigerians reduce their onion intake, ignoring the nutritional benefits of onions. Use of onion powder can reduce irritation in the eye during dish preparation. Employment opportunities for the farmers will be increased positively which will enables them to produce more onions for the production of onion powder. The limited value addition to fresh onion through processing into shelf-stable and commercially valuable products such as onion powder, flakes, and other processed forms further aggravates this problem. Consequently, a significant proportion of harvested onions deteriorates before reaching consumers, resulting in food waste, reduced income for farmers, and inefficient utilization of agricultural resources. This highlights the need for improved value-addition strategies that can extend the shelf life of fresh onion, reduce post-harvest losses, and enhance its economic value (Haruna et al., 2023). This research aims to reduce post-harvest losses by producing onion powder from fresh onion bulbs, and used as a component of selected culinary products. The specific objective was to determine the micronutrient (zinc, calcium, iron, cupper), phytochemical (total phenol, flavonoid, ascorbic acid and  $\beta$ - carotene) of the onion powder and carry out the sensory acceptability of culinary products made with dried onion powder compared to the fresh onion.

## **Materials and Methods**

### **Materials**

Fresh onions, eggs, vegetables, flour, beans and meat were purchased from Ota market in Ogun State Nigeria.

## Methods

### Onion Powder Preparation

The onion powder was produced using the Finis onion processing facility in the food processing laboratory, Department of Food Science and Technology, Bells University of Technology Ota, Ogun State. Fresh onion was cleaned and washed with distilled water to remove impurities and loaded into the onion processing line where the peels are removed. The peeled onions passed through the inspection table on a conveyor and improperly peeled onion recycled and thereafter into the auto-slicer where they are sliced into  $5 \pm 0.2$  mm thickness and dried using hot air-drying cabinet at  $55^{\circ}\text{C}$  for 24 h. The flakes are milled into fine powder using a grinder (Model: MX-AC400, Panasonic). The powder was sieved with a Lab Sieve (Model: BK-TS200, Biobase) with a  $150\ \mu\text{m}$  mesh, packaged in airtight containers and stored at room temperature until further analysis. The process flow diagram is shown in Figure 1

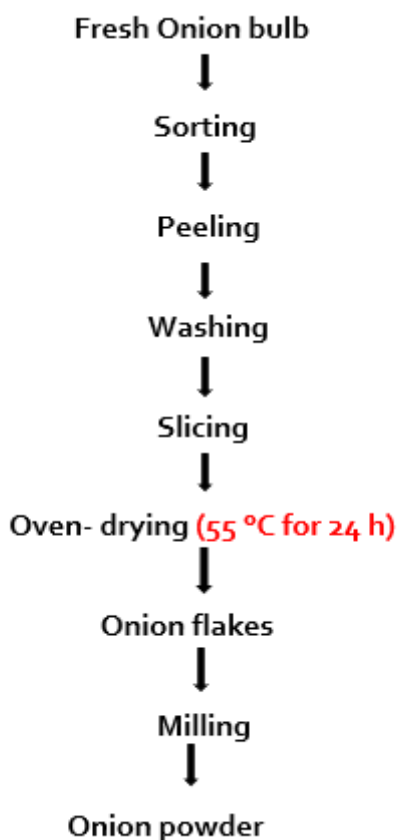


**Figure 1:** Flowchart for the production of onion powder (Edith *et al.*, 2018)

### Preparation of Scrambled Egg

Scrambled egg was prepared using 100 g of fresh red and white onion as controls while 20 and 40 g of red and white onion powder were used in the formulated samples: Egg (150g) was thoroughly whisked in a hollow bowl, 20 and 40g of red and white dried onion powder

was added followed by further whisking. About 50g of chopped vegetable leave and 5g of salt was mixed with the whisked egg. Vegetable oil (150ml) was added into non-stick frying pan and heated over medium-high until shimmering. The egg mixture was poured in, swirled around the pan to coat. Cooking was continued undisturbed for 5 seconds with gentle stirring with a heatproof wooden spoon in a circular motion for about 20 seconds until the curds are set. The pan was removed from heat and egg scraped onto a plate.

### **Preparation of Boiled Meat**

The boiled meat was prepared using 100 g of fresh red and white onion as control while 20 and 40 g of dried red and dried white onion powder was used in the formulated samples. About 300g beef was washed and rinsed under cold water, visible fat was removed. The washed beef was put in a clean pot. The beef was placed on low-medium heat, 20 and 40g of red and white dried onion powder and 100g fresh red and white onions (control) was added. Salt (3g), seasoning cube (4g) was added and properly stirred. About 100 ml of water was added. The pot was covered with a lid and simmered for 10 minutes.

### **Preparation of *moin-moin* (Beans Pudding)**

Beans pudding was prepared using 100 g of fresh red and white onion as control while 20 and 40 g of red and white onion powder was used in the formulated sample. The raw beans (200g) are added into a bowl after proper sorting and soaked in clean water for about 15min to soften the skin and facilitate wet dehulling carried out by squeezing with the hands. More water was added but not allow to soak the beans, squeezing and washing was repeated several times until every shade of coat was removed. The dehulled bean was washed and soaked for 45 min in clean water, followed by addition of 20 g of red paprika (*Capsicum annum*) previously splited in two halves to remove the seeds at the centre, this practice was necessary because the seeds add a bitter taste to the pudding. Refined vegetable oil (20ml), 20 and 40g red dried and white dried onion powder and 100g fresh red and white onions (control) was added and stirred for about 2 min. The mixture was portioned equally in hollow cups and positioned into the cooking pot containing water making sure it did not cover the cups used for portioning the mixture. The pot was cover tightly and cooked for about 60 minutes adding water at interval to avoid burning as well as prevent boiling water getting into the hollow cups. Once confirmed cooked the bean pudding was allowed to cool for 30 min and served

### **Preparation of Vegetable Stew**

Fresh pepper and tomato were rinsed and the red paprika deseeded because the seeds have a tendency to make the stew taste bitter. Deseeded red paprika (125g) and tomato (75g) were blended in a kitchen blender to a smooth paste. The blended peppers were poured into a pot and boiled till all the water evaporates. Vegetable oil (20 ml) was poured into a clean dry pot and heated up. Once very hot 20 and 40g of red and white onion powder as well as 100g fresh red and white onions (control) was added and stirred for 30 second to prepare each of the samples. The boiled pepper was added and fried (stirring from time to

time till there is no trace of water in the stew. Seasoning cube (4g) was added and allowed to cook for additional 5 min before the heat was turned off.

### **Preparation of Baked Pizza**

The pizza was produced with 100g fresh red onion and 100g fresh white onion as controls. Four formulated variants were produced using 20 and 40g red and white dried onion powder. The base formulation was 300 g wheat flour, sugar (about 6 g), refined salt (1g), soybean oil (20 ml), baker's yeast (3g), and portable water (75ml). The dry ingredients were weighed on a precision balance added and mixed in the kneading-trough at low speed for 1 min. After mixing the dry ingredients, water was incorporated and the dough mixed further on high speed (level 2) for 6-7 min to obtain a dough with even consistency. After appropriate gluten development, the dough was divided into 250 g portions, moulded and allowed to ferment for about 30min, passed through a disc of 0.5 cm thickness and then pressed to a diameter of 25 cm. Red and white onion powder (20 and 40g) and 100g fresh red and white onions (control) was added. Fifty gram of tomato sauce was evenly coated on the dough surface prior to baking. The dough was later loaded into an oven at a temperature of 230 °C and allow to bake for 20 min. The baked product was adequately cooled and sealed in an airtight plastic film bag and subsequently stored at room temperature.

### **Analysis**

The following analyses were carried out on the fresh and dried onion powder

#### **Determination of Proximate Composition of Fresh Onion and Dried Onion Powder**

The proximate composition of fresh onion and dried onion powder was determined using AOAC (2005) method. Briefly, moisture content was determined using oven method using 2 g sample and 105°C. The resulting dry matter was used to determine the other compositions. Crude protein (% total nitrogen x 6.25) was determined using the Kjeldahl method and crude fat was obtained using Soxhlet extraction method. Crude fibre was obtained by digesting the defatted sample in H<sub>2</sub>SO<sub>4</sub> and NaOH, respectively. Ash was achieved by incinerating the residue in a muffle furnace maintained at 550°C for 5h. Carbohydrates were determined by difference. Each determination was carried out in triplicate.

#### **Determination of Total Sugar**

Total sugar content was quantified using a modified Lane-Eynon volumetric method. Briefly, a 1 g sample of onion powder was combined with 50 ml of 80% ethanol and subjected to reflux extraction for 1 h. The matrix was then passed through a Buchner funnel, and the resulting filtrate volume was readjusted to 50 ml with 80% ethanol. The extracts were subsequently concentrated under reduced pressure using a rotary evaporator. Reducing sugars contained within a specified aliquot of the hydrolysed solution were

utilized to reduce the copper present in Fehling's solution. The Fehling's solution was pre-standardized against a standard invert sugar reference, and all quantitative evaluations were determined using the standard invert sugar reference table calculated for 10 ml of Fehling's solution. To minimize procedural and systematic errors, a standard sucrose solution (1.9 mg/ml) was analysed concurrently to establish an empirical correction factor by comparing experimental values against theoretical table values. The volumetric titration was maintained under continuous boiling conditions and completed strictly within a 3 min window to preclude any back-reaction. The discrepancy in volume between the standard sugar solution consumed during initial standardization and that required for the back-titration dictated the total sugar concentration, which was calculated according to Equation 1.

Total sugar (g per 100 g) =  $(F-M) \times I \times 250 \times 100 \times 100 / (W \times A \times 50)$  (Equation 1)

where, F is volume of standard sugar solution required to reduce 10 ml mixed Fehling's solution, M is volume of standard sugar solution used in back titration of the sample, I is gram sugar per ml working standard solution and W is weight of sample.

#### Determination of Energy Value of Onion Samples

Energy value was determined using the AOAC, (2005) method. This entailed multiplying the protein content by 4, carbohydrate content by 4 and fat content by 9.

#### Phytochemical Composition of Fresh and Dried Onion Powder

Total phenol, flavonoid, ascorbic acid and  $\beta$ - carotene of fresh and dried onion powder was determined as follows:

#### Determination of Total Phenolic Content (TPC)

Total phenolic content (TPC) was quantified following the Folin–Ciocalteu procedure described by Pérez et al. (2023). Briefly, a 1 ml aliquot of the extract was combined with 2 ml of 1 M Folin–Ciocalteu reagent and left to react for 5 min. Subsequently, 2 ml of 7.5% (w/v) sodium carbonate was introduced to the mixture, which was then thoroughly agitated and incubated at ambient temperature  $25 \pm 2^\circ\text{C}$  for 30 min. To clarify the mixture, the solution was centrifuged at  $2,000 \times g$  for 10 min using a benchtop centrifuge (Model 416G, Gyrozen, Republic of Korea). The absorbance of the resulting supernatant was recorded at 765 nm via a UV–Vis spectrophotometer (Model T60U, PG Instruments Limited, UK) against a reagent blank. Phenolic concentration was calculated using a standard gallic acid (Merck,  $\geq 98\%$  purity) calibration equation ( $y = 0.0903x + 0.0540$ ,  $R^2 = 0.9998$ ) and expressed as milligrams of gallic acid equivalents per gram of dry matter (mg GAE/g DM).

#### Determination of Total Flavonoid (TFC) Content.

Total flavonoid content (TFC) was determined via a modified aluminium chloride colourimetric assay based on the protocol by Bibi et al. (2022). A 10 g portion of onion powder was extracted using acetone and adjusted to a final volume of 1 ml. This aliquot was

combined with 4 ml of distilled water and left to react for 5 minutes. Subsequently, the mixture was treated with 0.3 ml of 5% (w/v)  $\text{NaNO}_2$  and 0.3 ml of 10% (w/v)  $\text{AlCl}_3$ , followed by a 6-min incubation period. After adding 2 ml of 1.0 M NaOH, the total volume was adjusted to 10 ml with distilled water. Following a final 15-minute incubation at room temperature, the absorbance was recorded at 510 nm against an extract-free reagent blank using a UV–Vis spectrophotometer (Model-T60U, PG Instruments Limited, UK). Flavonoid values were calculated using a high-purity standard calibration equation ( $y = 0.1504x + 0.0028$ ;  $R^2 = 0.9998$ ) obtained from Quercetin (Merck, purity  $\geq 95\%$ ) and expressed as milligrams of Quercetin equivalents per gram of dry matter (mg QE/g DM).

#### Determination of Ascorbic Acid

Ascorbic acid content was determined according to the spectrophotometric method described by Salkić et al. (2009). Briefly, a 1 g sample was homogenised for 2 min in 10 ml of 0.056 M sodium oxalate, allowed to precipitate for 5 min, and subsequently passed through filter paper. A 0.5 ml aliquot of the clear filtrate was diluted to a final volume of 5.0 ml using the same sodium oxalate solution. Absorbance profiles were recorded at 266 nm with a UV–Vis spectrophotometer (Model-T60U, PG Instruments Limited, UK) against a reference blank of 0.056 M sodium oxalate. Quantitation was performed using a standard calibration curve ( $y = 2.357x - 0.3683$ ;  $R^2 = 0.9998$ ) generated from high-purity L-ascorbic acid (Merck, purity  $\geq 95\%$ ), with values expressed as vitamin C content.

#### Determination of $\beta$ - carotene

The  $\beta$ - carotene was determined by the method of Mustapha (2008). One gram of sample was extracted in 50 ml of 95% ethanol at 70°C for 20 min before cooling, then the supernatant was transferred to a measuring cylinder for volume determination ( $V_1$ ). The mixture was adjusted to 85% ethanol with 15 ml of water, extracted using 25 ml of petroleum ether in a separating funnel, with the lower layer re-extracted five times with 10 ml of petroleum ether and washed with 50 ml of 80% ethanol, after which the final volume ( $V_2$ ) was measured for spectrophotometric analysis at 436 nm and  $\beta$ - carotene calculated using Equation 2.

$$\beta\text{- carotene (mg/g)} = \frac{\text{Abs} \times V_1}{\text{EC} \times 1 \times W} \quad (\text{Equation 2})$$

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#### Determination of Pungency

Pyruvic acid content was determined spectrophotometrically according to the method described by Razia et al. (2026). A 0.0125% (w/v) 2,4-dinitrophenylhydrazine (DNPH) working solution was prepared by dissolving 0.165 g of DNPH powder in 1000 ml of 2 N HCl. For sample preparation, 5 g of onion powder was homogenised with 5 ml of distilled water to extract the juice. A 0.5 ml aliquot of the expressed juice was subsequently treated with 1.5 ml of 5% (w/v) trichloroacetic acid (TCA) and incubated at room temperature for 10 min. Following incubation, the mixture was diluted by adding 18 ml distilled water and filtered.

For the colourimetric reaction, a 1 ml portion of the filtered homogenate was combined with 1 ml of the 0.0125% DNPH solution in a test tube. The mixture was incubated in a water bath at 37 °C for 15 min, after which the reaction was terminated and the colour developed by adding 5 ml of 0.6 N NaOH. The absorbance of the final solution was measured using a spectrophotometer at 420 nm. Pyruvic acid concentrations were quantified against a standard calibration curve generated using sodium pyruvate and calculated using Equation 3.

$$\mu \text{ moles pyruvic acid/g} = \mu \text{ moles/ml (read from standard curve)} \times \text{Total dilution (Equation 3)}$$

#### Determination of Mineral Content in Fresh and Dried Onion Powder Samples

Mineral compositions in the samples were determined using an atomic absorption spectrophotometer (Varian Techtron Model AAS 1000, Varian Associates, Palo Alto, CA) based on AOAC (2005) method in triplicates

#### Sensory Evaluation

A qualitative descriptive analysis was used to evaluate the products prepared with onion samples for color, taste, flavor pungency and overall acceptability. The organoleptic evaluation of the product prepared with onion samples was carried out using 30 semi-trained panellists. The panelists were provided with a questionnaire to evaluate the samples using the above-mentioned sensory properties based on a nine-point hedonic scale, where 1 was "dislike extremely", and 9 was "like extremely".

#### Statistical Analysis

All experiments were performed in triplicate, and the results obtained were expressed as means  $\pm$  standard deviation. The data obtained were analysed and interpreted by analysis of variance (ANOVA) and data means were separated using Duncan's Multiple Range Test (DMRT) at a level of 5% significance based on Statistical Package for Social Sciences software (SPSS, version 26, IBM).

#### Results

##### Proximate Composition of Fresh and Dried Onion Powder

The proximate analysis of red and white onion bulbs shown in Figure 2 indicated 82.99 and 82.42 % moisture content which is higher than the findings of Dinkecha et al. (2017) who reported values between 73.74 and 77.31 % on five Ethiopian onion *Allium cepa* varieties. Onion is known to have high moisture content which underscored its perishability and susceptibility to microbial spoilage. The high moisture content of fresh onion indicates that they should be preserved properly. Armand et al. (2018) reported average moisture of 7% in onion powder, which contrast the values recorded in this work. This may be due to difference in variety, drying temperature, duration in oven and the thickness of sliced onion during drying. The protein content 6.34 and 6.53 % in fresh red and white onion, with 7.42 and 7.92% recorded in dried red and white onion powder respectively were not significantly

different. (Figure 1). Fat is low in fresh (0.65-0.72%) and (0.75-0.86%) dried onion powder in both varieties. These results are higher than 0.4% reported by Bhattacharjee et al. (2013). This implied that varieties used in this study are marginally higher in fat. This is associated with edaphic conditions which are unfavourable to a good production of lipids during the cultivation. Lipids are nutritionally essential as source of energy, supply of essential fatty acids as well as fat-soluble vitamins. The crude fibre content in the fresh and dried onion powder samples are significantly different with the white onion powder having higher values in fresh onion 4.20 and 5.20% in dried onion powder. The white onion with higher crude fiber will improve protection against constipation and prevents cardiovascular disease because studies have shown that soluble fiber lowers levels of artery-clogging cholesterol in the blood stream (Kim et al., 2023). The carbohydrate content ranged from 9.34% in raw onion to 79.12 % in onion powder. The carbohydrate and ash contents were comparable and did not indicate any remarkable difference ( $p < 0.05$ ) between the onion varieties. Cozma et al. (2025) reported that onion powder's high carbohydrate content is beneficial to life because in addition to providing energy, carbohydrates are required in a variety of biochemical reactions that are not directly related to energy. Thus, the carbohydrate levels in the samples suggest their importance as alternative source of glucose. Lipid contents in the onion bulbs was low and not significantly ( $p < 0.05$ ) different (Figure 2). The values were however not comparable to the findings of Armand et al. (2018) who reported between 2.06 and 4.31% in white of galmi, violet of galmi and goudami varieties using the Fourier transform infrared (FT-IR) spectroscopy. The difference may be associated geographical locations, agronomic practices and methods of analysis. The inorganic residues left after full oxidation of organic materials in the samples are referred to as ash content, and it provides an overview of the mineral composition of the sample. In the present study, both varieties exhibited high ash content. The ash content in the red and white onion varieties are not different and not significantly affected by drying. The red and white onion *Allium cepa*. L used in this study could be promising sources of essential mineral elements due to higher ash content which ranged between 1.42% in dried sample to 1.92% in fresh samples.

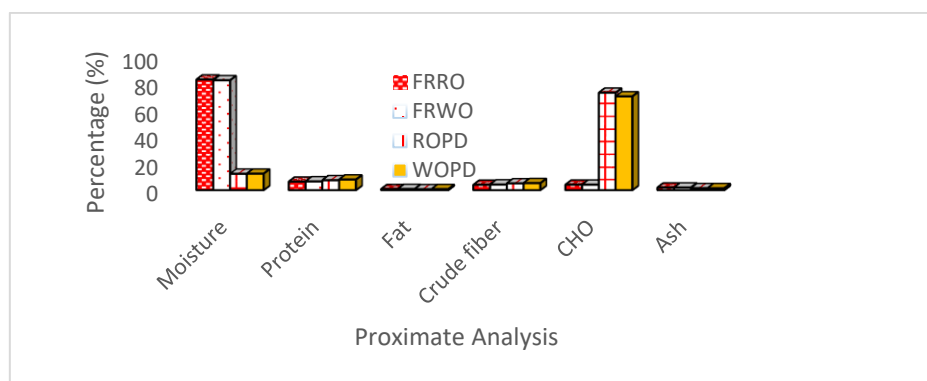


**Figure 2:** Proximate composition of fresh onion and dried onion powder samples.  
**Source:** Authors experimental findings 2026

FRRO: Fresh Red Onion

FRWO Fresh White Onion

ROPD: Red Onion Powder

WOPD White Onion Powder

### Sweetness, Pungency, and Total Energy Values of Fresh Onion and Dried Onion Powder

The total sugar contents in the fresh onion and dried onion powder *Allium cepa* L. was significantly high ( $p < 0.05$ ) with the highest value 9.54 % in fresh white and 7.53% in the dried white onion powder as shown in Table 1. These values are comparable to findings of Bogevska et al. (2016) in sweet onion landrace '*Buchinska arshlama*'. The white onion used in this research taste sweeter than the red onion variety. Lee et al. (2009) established that there were no linear relationships between the pungency level and individual or total sugar contents though onion has both glucose (reducing sugar) and sucrose (non-reducing sugar) both of which contribute to the sweetness. As shown in Table 1 the fresh onions presented a higher sugar content than dried samples, the sugar content decreased with drying, and the trend was similar because about 30 % of the sugar was lost during drying due to non-enzymatic browning, a reaction between free amino groups of proteins and reducing sugars that produce a brown colour (Sharma et al., 2015).

Onion pungency is primarily driven by an array of volatile organosulfur compounds. These constituents are synthesized upon mechanical disruption of the onion tissue, which facilitates contact between the cytoplasmic enzyme alliinase and its corresponding flavour precursors, the S-alk(en)yl-cysteine sulfoxides. Concurrently with the formation of these volatile sulfur species, the enzymatic cleavage of S-alk(en)yl-cysteine sulfoxides yields stoichiometric quantities of ammonia and pyruvic acid. Consequently, the concentration of pyruvic acid generated enzymatically during mechanical homogenization serves as an accurate biochemical index of alliinase activity on flavour precursors, exhibiting a robust correlation with sensory-perceived onion pungency. A useful indicator of pungency is therefore pyruvic acid and may be classified according to Gupta et al.(2025) as very sweet (1-4 $\mu$ mol pyruvic acid/g); sweet (5-7 $\mu$ mol pyruvic acid/g); intermediate pungency (8-10  $\mu$ mol pyruvic acid/g); pungent (11-15 $\mu$ mol pyruvic acid/g) very pungent (>15 $\mu$ mol pyruvic acid/g). The Pyruvic acid in the fresh red and white onion are 72.67 and 88.43  $\mu$ mol/g and dried red and white onion powder 55.23 and 66.20  $\mu$ mol/g were significantly different ( $p < 0.05$ ) as shown in Table 1. In this work, all samples are classified as very pungent with the white onion variety having higher values providing clear evidence of genetic variation. The concentration of pyruvic acid and by extension the pungency decreased with increase in drying temperature of 55°C due to the low boiling point of most volatile compounds. This trend is reported by Seifu et al. (2018) in Bombay red, Qellafo and Sweet carolin onions dried at temperatures between 50 and 90°C. In this study about 25% loss in pungency was observed with drying in fresh red and white onion varieties hence there is a significant difference ( $p < 0.05$ ) with the dried onion powder having a higher value.

The retention of pungency in dehydrated onion matrices is highly contingent upon the specific processing conditions and thermal profiles applied during drying, as pyruvic acid

molecules undergo thermal degradation at elevated temperatures. Beyond processing parameters, the baseline pyruvic acid content in onions is modulated by agronomic and biological variables, including cultivar selection, carbohydrate profiles, total dry matter content, sulfur fertilization regimes, and stage of physiological maturity. Chemically, pyruvic acid functions as a highly stable, stoichiometric end-product derived from the hydrolysis of S-alk(en)yl-L-cysteine sulfoxides. Upon cellular disruption or mechanical shearing caused by slicing and chopping, the compartmentalized enzyme alliinase is liberated to hydrolyse these S-alk(en)yl-L-cysteine sulfoxide precursors, thereby releasing volatile flavour compounds alongside equimolar quantities of pyruvate and ammonia (Lancaster & Boland 2020). Onions used in this study showed higher energy value. The total energy values in the fresh red and white onion (53.12, 60.25 kcal/100g) are significantly different ( $p < 0.05$ ) with the white onion having a higher caloric value. This value is low compared to Shovon et al. (2013) who reported more than 72 kcal /100g in two onion cultivars. Dinkecha et al. (2017) also reported between 109 and 166 kcal/100g in different red onion (*Allium cepa* L.) varieties grown at same field management condition in Ethiopia. The significantly different ( $p < 0.05$ ) total energy recorded in the dried onion powder with higher value (48.16 kcal/100g) recorded in the white powder may be associated with the higher total sugar content in the white onion used in this study.

**Table 1: Sweetness, pungency, and total energy values of fresh onion and dried onion powder**

| Sample | Total sugar (%) | Pyruvic acid ( $\mu\text{mol/g}$ ) | Total energy (Kcal / 100 gm.) |
|--------|-----------------|------------------------------------|-------------------------------|
| FRRO   | $8.66 \pm 1.15$ | $72.67 \pm 0.01$                   | $53.12 \pm 2.15$              |
| FRWO   | $9.54 \pm 1.02$ | $88.43 \pm 0.05$                   | $60.25 \pm 4.15$              |
| ROPD   | $6.19 \pm 0.32$ | $53.23 \pm 0.03$                   | $43.55 \pm 0.18$              |
| WOPD   | $7.53 \pm 0.42$ | $66.20 \pm 0.07$                   | $48.16 \pm 0.15$              |

**Source:** Authors experimental data 2026.

**Note.** Within each column, means sharing the same letter are not significantly different at the 5% level of significance using Tukey's multiple means comparison method

### Legend

FRRO: Fresh Red Onion

FRWO Fresh White Onion

ROPD: Red Onion Powder

WOPD White Onion Powder

### Phytochemical Composition of Fresh Onions and Dried Onion Powder

Phytochemical composition of fresh and dried onion powder samples showed significant ( $p < 0.05$ ) difference in total phenol with the highest value 70.64 GAE/g recorded in the fresh red and 68.72 GAE/g recorded in the white onion. These values are low compared to the findings of Dalamu et al. (2010) who reported 417.4 to 1469  $\mu\text{g}$  GAE/g as the average total

phenolic content in different cultivars of onions. Our results is low compared to Gokce et al. (2010) who reported between 90 to 130 µg GAE/g for white variety. The phenolic compound includes a wide range of compound in plant, with aromatic ring with one or more hydroxyl components in common. They most frequently occur combined with sugar glycoside located in the cell vacuole. Onion is a source of phenolic derived through cinnamic or benzoic acid which are found either in free or bound form and responsible for the colour, taste, bitterness, and aroma of plants. In this study the phenols are lost with drying as the white onion cultivar recorded more than 40 % (Figure 2a). The total flavonoids in fresh red (133.25 QE/g) and white (102.12 QE/g) as well as dried red (94.91 QE/g) and white (85.44 QE/g) onion powder are significantly ( $p < 0.05$ ) different (Figure 2b). These values are higher compared to Elhassaneen, (2006) who reported 70.38 and 32.49 QE/g in white Giza-6 and red Giza-20 onions obtained from Egyptian local markets. Comparing red cultivars to white cultivars, we found that red cultivars had the highest concentration of TFC. The value obtained is comparable to Zhang et al. (2016) who reported (111.10 mg QE/g) in three different coloured onions, similarly the red cultivar had higher TFC compared to the white cultivar. Two flavonoids and subgroup are found in onion, the anthocyanin which impart a red/purple colour to some varieties, and quercetin (which exists in free as well as in conjugate form with carbohydrate, mainly as glycosidase) and kaempferol, responsible for the yellow and brown skins of many varieties (Ben Alaya et al., 2024). As shown in Figure 2b the fresh red and dried onion powder contained higher levels in this study. Major flavonoids in both onion varieties are quercetin compounds, quercetin-3,4'-diglucosides and quercetin-4'- glucoside. Several studies reported that the red bulb colour is influenced by anthocyanin contents (Mirzazadeh et al., 2024). It has been demonstrated that humans absorb part of the quercetin glucosides accumulating them as quercetin conjugates in the blood plasma (Williamson and Clifford 2025). *In vitro* investigations demonstrate that quercetin effectively mitigates the oxidation of low-density lipoproteins (LDL) through the direct scavenging of reactive oxygen species (ROS). The broad functional and therapeutic profile of this flavonoid includes documented anti-inflammatory, antihistaminic, anti-allergic, antineoplastic, and antiviral activities. Furthermore, clinical evidence suggests that quercetin supplementation modulates endothelial function and aids in blood pressure regulation among hypertensive cohorts (Vafadar et al., 2020). There was significant ( $p < 0.05$ ) difference in the result of ascorbic acid in the fresh and dried onion powder samples with the fresh red and dried onion powder indicating the highest concentration of 21.94 and 9.09 mg/100g respectively (Figure 2c). These findings align closely with observations by Wang et al. (2024), who established that the ultimate quality of dehydrated vegetable matrices is heavily dictated by their restorability, or their capacity to reconstitute toward their original state during rehydration. The variations observed across samples may stem from discrepancies in cultivar selection as well as the specific dehydration technologies deployed during powder production. Furthermore, the vulnerability of ascorbic acid to thermal processing noted in this study corroborates the findings of Seifu et al. (2018), confirming the structurally destructive impact of elevated temperatures on heat-sensitive vitamins. Colour variation in cultivars and physical treatment affects ascorbic acid content

(Al-Khafaji. 2019; Seifu et al., 2018) which was observed in this study as more than 50 % of ascorbic acid was lost due to drying. Ascorbic acid is considered nutritionally important in processed food but has low stability during food processing, especially in heat treatment (Yin et al., 2022). Ascorbic acid is an antioxidant whose role is crucial in the fight against stress (Jamshidovich,2023). There was significant ( $p < 0.05$ ) difference in  $\beta$  – carotene in the fresh and dried onion powder samples with the fresh red and dried onion powder indicating the highest concentration of 0.26 and 0.19 mg/100g respectively (Figure 2d). The carotenoid compositions of the fresh red and white onion samples were significantly ( $p < 0.05$ ) altered after drying. Results showed that the  $\beta$  – carotene concentrations of fresh red and white onion decreased by more than 70 percent. However, it is interesting to point out that the red onion samples had the highest  $\beta$  – carotene concentrations in comparison to the white variety. This result is comparable to Salamatullah et al. (2021) in white and red-skinned onion slices.

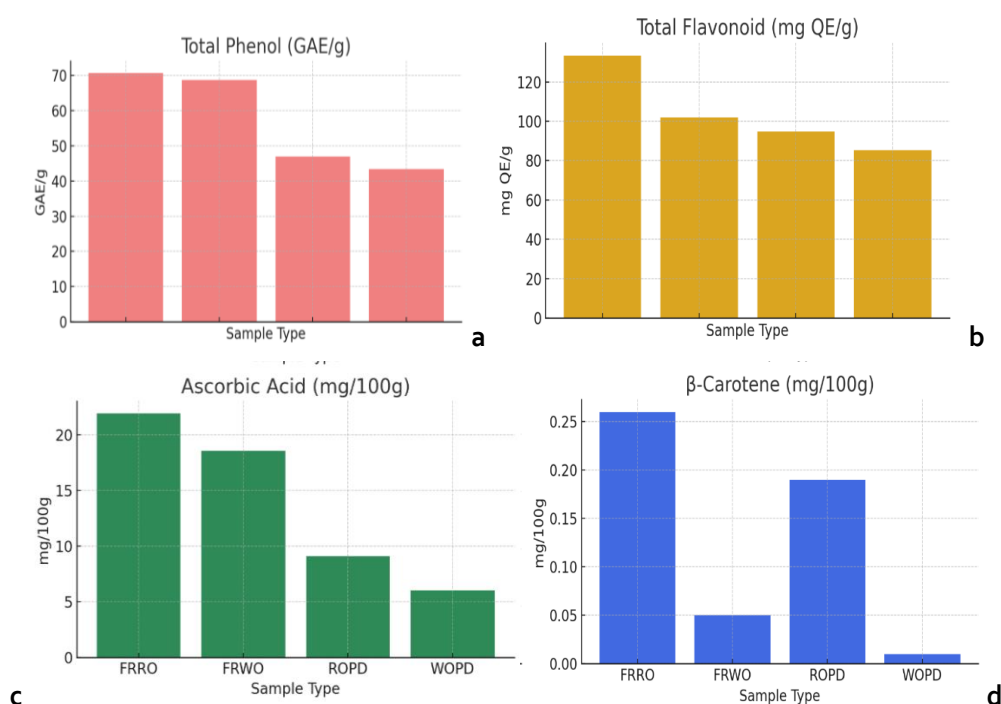


**Figure 2:** Phytochemical composition of fresh onions and dried onion powder Values are mean  $\pm$  standard deviation of three determinations.

**Source:** Authors experimental data 2026

### Legend

FRRO: Fresh Red Onion

FRWO Fresh White Onion

ROPD: Red Onion Powder

WOPD: White Onion Powder

### Mineral Composition of Fresh and Dried Onion Powder

There was significant ( $p < 0.05$ ) difference in the concentration of minerals with calcium and potassium occurring as dominant in the fresh red and white onion bulbs as well as in the dried red and white onion powder. Drying results in about 10% increase in calcium concentration, though fractional increases were also recorded in the concentration of iron, copper, and zinc in both cultivars. The general order of the mineral content in the fresh red and white onion as well as the dried red and white onion powder is  $\text{Ca} > \text{K} > \text{Zn} > \text{Fe} > \text{Cu}$ . (Figure 3). The values obtained for iron, copper, potassium and zinc is comparable to the findings of Akinwande and Olatunde, (2015) in Dan Zaria, red creole and white creole cultivars (*Allium cepa* L.) obtained from Northern Nigeria. These values confirmed the earlier reports that potassium is one of the most abundantly available elements in Nigerian agricultural produce (Remi, 2023). The value obtained for calcium in the dried red and white onion powder (182.76 and 174.22 mg/100g) is higher compared to the findings of Kefale et al. (2023) who reported 71.16 mg/100g dried red onion powder obtained from Agricultural Research Centre, Ethiopia. The high concentration of calcium and potassium in the red and white onions in this study may be associated with type of fertilizer used during cultivation as well as the geographical location and agronomic practices. The quality of onion, physiology and production is influenced by fertilization with N, P and K containing fertilizers. In addition to skeletal function, calcium plays a regulatory role in a number of specialised functions in the body including cardiac muscle contraction, neurotransmitter secretion, digestion and blood coagulation (Malik et al., 2023). Potassium is an essential nutrient that performs a vital role in cellular functions including maintaining fluid balance and osmolality of cells (McLean and Wang, 2021). Iron facilitates the transportation of oxygen throughout the bloodstream via haemoglobin in erythrocytes (Sousa et al., 2020). Copper and zinc are two essential micro minerals available in the diet and are required in small amounts between 1–100 mg/day. Zinc, a component of various enzyme systems is required for protein health, immune function, and wound healing (Gunturu and Dharmarajan, 2020).



**Figure 3:** Mineral composition of fresh onion and dried onion powder samples Values are mean  $\pm$  standard deviation of three determinations.

**Source:** Authors experimental data 2026

### Legend

FRRO: Fresh Red Onion

FRWO Fresh White Onion

ROPD: Red Onion Powder

WOPD: White Onion Powder

### Sensory Evaluation

There were significant ( $p < 0.05$ ) differences in colour, taste, flavor, pungency and overall acceptability of bean pudding prepared with 20 and 40 g red onion (BPTRO, BPFRO) and white onion (BPTWO, BPFWO) powder. Bean pudding prepared with 100g fresh red (BPCOR) and white (BPCOW) onion recorded the highest mean value for taste (7.70, 7.20), flavor (7.80, 7.80) pungency (7.80, 7.83) and overall acceptability (8.10, 8.90). The panelist preferred beans pudding prepared with 100g fresh red and white onion as shown in Table 2. Scrambled egg prepared with 40g dried red (SEFRO) and white (SEFWO) onion powder showed the highest mean value in overall acceptability (7.90), however there was no significant ( $p > 0.05$ ) difference in the panelist rating for colour, taste flavor and pungency. This implies that onion variety and drying does not affect the preference of the panelist for these sensory attributes. In boiled meat samples, there was no significant ( $p > 0.05$ ) difference in colour and taste in samples prepared with 20g (BMTRO, BMTWO) and 40g (BMFRO, BMFWO) dried red and white onion powder, whereas significant ( $p < 0.05$ ) difference was recorded in flavor, pungency and overall acceptability. The panelist preferred boiled meat prepared with 100g fresh red (BMCOR) and white (BMCOW) onion as shown in Table 2 with the mean overall acceptability values of 7.90 and 7.91 respectively. There was no was significant ( $p > 0.05$ ) difference in colour but a significant difference was recorded for taste, flavor, pungency and overall acceptability of pizza prepared with 20 and 40 g of red (PITRO, PIFRO) and white (PITWO, PIFWO) onion powder. Pizza prepared with 100 g white onion (PICOW) showed the highest mean value in taste (8.34), flavor (8.12) pungency (8.28) and overall acceptability (8.97). The panelist preferred pizza prepared with 100 g fresh white onion. Vegetable soup prepared with the fresh and dried onion was not affected by variety nor dryness of the onion as there was no significant ( $p > 0.05$ ) difference in colour. There was significant ( $p < 0.05$ ) difference in taste, flavor, pungency and overall acceptability of vegetable soup. The sensory acceptability of vegetable soup prepared with 20 and 40 g red (VSTRO, VSFRO) and white onion powder were rated low in taste (5.70, 6.20 and 5.23, 6.43) flavor (5.00, 6.90 and 5.12, 6.99) pungency (6.70, 7.20 and 6.88, 7.82). Results indicate that the addition of 20 and 40g dried onion powder has little effect on the sensory attributes of the vegetable stew. This might be due to loss volatiles which are the main precursors of onion flavour (Benítez *et al.* 2011). The overall acceptability of vegetable soup prepared with 20g red dried onion powder (VSTRO) was higher than fresh and dried onion powder samples. An interesting observation from this study is that sensory attributes such as colour, taste, flavour and pungency of the various culinary products were not affected by the onion varietal differences. Drying affects the colour of onion powder due to Maillard

browning reactions during the drying process though the effect of this loss is not pronounced in the overall acceptability of culinary products made from the fresh and dried onion powder used in this study

**Table 2: Sensory evaluation of selected products prepared with onion samples**

| Sample | Colour                             | Taste                    | Flavor                   | Pungency                | Overall acceptability     |
|--------|------------------------------------|--------------------------|--------------------------|-------------------------|---------------------------|
| BPTRO  | 6.00±0.82 <sup>c</sup>             | 5.60±0.96 <sup>bc</sup>  | 7.00±0.81 <sup>c</sup>   | 5.50±1.17 <sup>ab</sup> | 6.00±0.86 <sup>bcd</sup>  |
| BPTWO  | 6.20±0.85 <sup>c</sup>             | 5.00±0.99 <sup>bc</sup>  | 7.33±0.83 <sup>c</sup>   | 5.55±1.18 <sup>ab</sup> | 6.12±1.11 <sup>cd</sup>   |
| BPFRO  | 7.40±1.17 <sup>abc</sup>           | 6.50±1.26 <sup>bc</sup>  | 7.40±1.14 <sup>abc</sup> | 7.00±1.09 <sup>a</sup>  | 7.10±1.11 <sup>cd</sup>   |
| BPFWO  | 7.40±1.12 <sup>abc</sup>           | 6.96±1.22 <sup>bc</sup>  | 7.20±1.23 <sup>abc</sup> | 7.00±1.03 <sup>a</sup>  | 7.88±0.09 <sup>bcd</sup>  |
| BPCOR  | 7.80±0.78 <sup>ab</sup>            | 7.70±0.83 <sup>ab</sup>  | 7.80±0.78 <sup>ab</sup>  | 7.80±1.03 <sup>a</sup>  | 7.10±0.94 <sup>abc</sup>  |
| BPCOW  | 7.70±0.67 <sup>ab</sup>            | 7.22±0.90 <sup>ab</sup>  | 6.00±0.88 <sup>ab</sup>  | 7.83±1.04 <sup>a</sup>  | 8.90±0.99 <sup>bcd</sup>  |
| SETRO  | 7.40±0.84 <sup>3ab</sup>           | 5.20±1.03 <sup>abc</sup> | 5.30±0.94 <sup>abc</sup> | 7.60±0.96 <sup>a</sup>  | 7.60±0.66 <sup>abcd</sup> |
| SETWO  | 7.64 ±0.88 <sup>ab</sup>           | 5.32±0.99 <sup>bc</sup>  | 5.50±1.11 <sup>abc</sup> | 7.77±0.88 <sup>ab</sup> | 7.98±1.12 <sup>abcd</sup> |
| SEFRO  | 7.80±0.83 <sup>ab</sup>            | 7.70±0.82 <sup>bc</sup>  | 6.70±1.09 <sup>bc</sup>  | 7.60±0.96 <sup>a</sup>  | 7.90±0.73 <sup>bcd</sup>  |
| SEFWO  | 7.88±1.22 <sup>ab</sup>            | 7.76±0.89 <sup>bc</sup>  | 6.80±1.20 <sup>bc</sup>  | 7.67±1.10 <sup>a</sup>  | 7.90±0.74 <sup>bcd</sup>  |
| SECOR  | 7.30±1.77 <sup>ab</sup>            | 7.60±0.96 <sup>bc</sup>  | 6.50±1.35 <sup>abc</sup> | 7.70±0.99 <sup>a</sup>  | 7.50±1.59 <sup>abcd</sup> |
| SECOW  | 7.34±1.77 <sup>ab</sup>            | 7.66±0.96 <sup>bc</sup>  | 6.65±1.44 <sup>abc</sup> | 7.77±1.36 <sup>a</sup>  | 7.76±1.60 <sup>abcd</sup> |
| BMTRO  | 7.20±1.03 <sup>b</sup>             | 8.10±0.94 <sup>c</sup>   | 8.00±1.04 <sup>c</sup>   | 7.90±1.37 <sup>a</sup>  | 7.30±0.94 <sup>d</sup>    |
| BMTWO  | 7.25±1.13 <sup>a<sup>b</sup></sup> | 6.22±0.99 <sup>c</sup>   | 8.05±1.11 <sup>ab</sup>  | 6.66±1.43 <sup>ab</sup> | 7.44±0.91 <sup>d</sup>    |
| BMFRO  | 7.60±1.17 <sup>a</sup>             | 6.30±1.44 <sup>a</sup>   | 6.50±1.17 <sup>a</sup>   | 6.80±1.03 <sup>a</sup>  | 7.50±1.58 <sup>a</sup>    |
| BMFWO  | 7.66±1.20 <sup>a</sup>             | 6.66±0.76 <sup>ab</sup>  | 6.67±1.18 <sup>a</sup>   | 6.67±1.04 <sup>a</sup>  | 7.72±1.66 <sup>a</sup>    |
| BMCOR  | 7.10±1.19 <sup>ab</sup>            | 7.10±1.11 <sup>abc</sup> | 6.80±0.91 <sup>ab</sup>  | 6.90±0.86 <sup>a</sup>  | 7.90±1.27 <sup>ab</sup>   |
| BMCOW  | 7.12±0.09 <sup>ab</sup>            | 7.23±0.98 <sup>abc</sup> | 7.98±1.32 <sup>ab</sup>  | 7.76±0.90 <sup>a</sup>  | 7.91±1.22 <sup>ab</sup>   |
| PITRO  | 7.70±0.99 <sup>ab</sup>            | 7.70±1.05 <sup>bc</sup>  | 7.70±1.05 <sup>bc</sup>  | 7.60±1.05 <sup>ab</sup> | 7.80±0.91 <sup>bcd</sup>  |
| PITWO  | 7.68±0.99 <sup>ab</sup>            | 7.75±1.75 <sup>abc</sup> | 7.56±0.66 <sup>abc</sup> | 7.77±1.09 <sup>a</sup>  | 7.76±0.95 <sup>bcd</sup>  |
| PIFRO  | 7.50±0.92 <sup>ab</sup>            | 7.20±0.99 <sup>abc</sup> | 7.30±0.65 <sup>abc</sup> | 7.20±0.99 <sup>a</sup>  | 7.60±0.96 <sup>abcd</sup> |
| PIFWO  | 7.67±1.23 <sup>ab</sup>            | 7.55±1.06 <sup>abc</sup> | 7.33±0.76 <sup>abc</sup> | 7.19±1.01 <sup>a</sup>  | 7.67±0.97 <sup>abcd</sup> |
| PICOR  | 7.66±1.03 <sup>ab</sup>            | 7.30±1.05 <sup>abc</sup> | 7.00±0.93 <sup>abc</sup> | 7.15±1.08 <sup>a</sup>  | 8.80±1.29 <sup>bcd</sup>  |
| PICOW  | 7.68±1.05 <sup>ab</sup>            | 8.34±1.07 <sup>abc</sup> | 8.12±1.10 <sup>abc</sup> | 8.28±1.12 <sup>a</sup>  | 8.97±1.43 <sup>abc</sup>  |
| VSTRO  | 7.70±1.16 <sup>ab</sup>            | 5.70±0.94 <sup>bc</sup>  | 5.00±0.86 <sup>c</sup>   | 6.70±1.09 <sup>a</sup>  | 8.30±0.67 <sup>d</sup>    |
| VSTWO  | 7.77±1.16 <sup>ab</sup>            | 5.23±0.89 <sup>bc</sup>  | 5.12±0.92 <sup>c</sup>   | 6.88±1.11 <sup>ab</sup> | 6.24±0.75 <sup>cd</sup>   |
| VSFRO  | 7.80±0.87 <sup>ab</sup>            | 6.20±0.91 <sup>abc</sup> | 6.90±0.86 <sup>ab</sup>  | 7.20±1.03 <sup>a</sup>  | 7.00±1.27 <sup>abc</sup>  |
| VSFWO  | 7.80±0.85 <sup>ab</sup>            | 6.43±1.12 <sup>abc</sup> | 6.99±0.99 <sup>ab</sup>  | 7.82±1.17 <sup>ab</sup> | 6.87±1.05 <sup>abc</sup>  |
| VSCOR  | 7.50±1.26 <sup>ab</sup>            | 7.80±0.91 <sup>bc</sup>  | 7.60±0.96 <sup>bc</sup>  | 7.60±1.25 <sup>a</sup>  | 7.80±1.37 <sup>abc</sup>  |
| VSCOW  | 7.58±1.26 <sup>ab</sup>            | 7.88±0.95 <sup>bc</sup>  | 7.77±1.11 <sup>bc</sup>  | 7.88±1.33 <sup>ab</sup> | 7.55±1.39 <sup>ab</sup>   |

Means ±Standard deviation on the same column within each variable following by different letters differed significantly (p < 0.05) as determined by Duncan's multiple range test.

Source: Authors experimental findings 2026

### Legend

BPTRO- Beans pudding made with 20 g of red onion powder

BPTWO-Beans pudding made with 20 g of white onion powder

BPFRO- Beans pudding made with 40 g of red onion powder  
 BPFWO -Beans pudding made with 40 g of white onion powder  
 BPCOR -Beans pudding made with 100g fresh red onion  
 BPCOW- Beans pudding made with 100g fresh white onion  
 SETWO Scrambled egg made with 20 g of white onion powder  
 SEFRO Scrambled egg made with 40 g of red onion powder  
 SEFW Scrambled egg made with 40 g of white onion powder  
 SECOR Scrambled egg made with 100g fresh red onion  
 SECOW Scrambled egg made with 100g fresh white  
 BMTRO- Boiled meat made with 20 g of red onion powder  
 BMTWO- Boiled meat made with 20 g of white onion powder  
 BMFRO -Boiled meat made with 40 g of red onion powder  
 BMFWO Boiled meat made with 40 g of white onion powder  
 BMCOR Boiled meat made with 100g fresh red onion  
 BMCOW Boiled meat made with 100g fresh white onion  
 PITRO Pizza made with 20g of red onion powder  
 PITWO Pizza made with 20g white onion powder  
 PIFRO Pizza made with 40g red onion powder  
 PIFWO Pizza made with 40g white onion powder  
 PICOR Pizza made with 100g fresh onion  
 PICWO Pizza made with 100g white fresh onion  
 VSTRO- Vegetable soup made with 20 g of red onion powder  
 VSTWO- Vegetable soup made with 20 g of white onion powder  
 VSFRO- Vegetable soup made with 40 g of red onion powder  
 VSFWO - Vegetable soup made with 40 g of white onion powder  
 VSCOR - Vegetable soup made with 100g fresh red onion  
 VSCOW- Vegetable soup made with 100g fresh white onion

## Conclusion

In this study, the high moisture content of fresh onion indicated that they should be preserved properly as they are prone to deterioration resulting in spoilage and a short shelf life. The fresh red and white onion as well as the dried onion powder are marginally higher in crude fiber and fat though onions are known to be low in fat. Total sugar was higher in the fresh white onion bulb and the fresh red and white onion varieties showed higher energy value than the dried onion powder. The carbohydrate and ash contents were comparable and did not indicate any remarkable difference between the two varieties. The red and white onion samples are classified as very pungent with the white onion variety having higher values though concentration of pyruvic acid and decreased with drying. The fresh red onion recorded higher macro elements concentration while the trace element predominates in the fresh white onion. The phytochemical composition in the fresh and dried onion powder samples showed significant differences in total phenol with the highest

value recorded in the fresh red. The red and dried onion powder contained higher flavonoids levels. There was significant difference in the ascorbic acid and  $\beta$  – carotene concentrations with the fresh red and dried onion powder indicating highest concentration compared to the dried onion powder. Bean pudding, boiled meat and pizza prepared with fresh red and white onion recorded the highest mean value for overall acceptability. Scrambled egg prepared with 40g dried red and white onion powder showed the highest mean value in overall acceptability, however no significant difference was recorded for colour, taste flavor and pungency. Drying affects the colour of onion powder however the effect was not pronounced in the overall acceptability of culinary products in this study

## Recommendations

The following recommendations are suggested to translate the findings into practical guidance for food processors and policymakers. Food processors should promote onion powder as a value-added ingredient into suitable Nigerian culinary products to improve product variety, enhance flavor, and create convenient alternatives to fresh onion. This inclusion must be carried out at levels that maintain the nutritional and phytochemical benefits of the products without compromising sensory acceptability, particularly color, aroma, taste, and overall acceptability. Government agencies should encourage investment in onion processing technologies, particularly drying and powder production, to reduce postharvest losses and improve the utilization of surplus onions at peak seasons.

## Data Availability

The authors did not use data that requires depositing in any repository in the course of this research work.

## Declaration of Competing Interest

The authors of this article declare that there are no conflicts of interest that could have inappropriately influenced this work.

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## Data Availability

"The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request."

## Author Contributions

Alamu A.E.: Conceptualization, Methodology, Writing – Original Draft. Olutayo O.K.: Formal Analysis: Tajudee R.A.: Visualization, Writing – Review & Editing. Olotu T A.: Supervision, Anaemene D.I: Project Administration.

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