Impact of blanching and two drying methods on the nutritional, organoleptic and microbiological properties of fresh onions of the Galmi violet variety sold on the markets of Korhogo (Côte D'Ivoire)

ABSTRACT

Onions (Allium cepa L.) are cultivated in many countries around the world for their nutritional, therapeutic and economic importance, but preservation remains a major problem due to their high perishability. Processing this vegetable could provide a solution to reduce post-harvest losses during periods of abundance. The aim of this work is to contribute to the reduction of post-harvest losses of fresh onions, with a view to enhancing their value. To this end, the influence of two drying methods (sun and shade), organoleptic qualities and microbiological characteristics were studied. Onions were subjected to two types of pre-treatment (boiling water blanching and steam blanching) and to 7 days drying at a temperature of 33°C in the sun and at room temperature. The results of biochemical analysis reveal that drying significantly reduces the water content of fresh onions from 83.23% to 14.49%. There was also a variation in ash content from 1.84 to 4.84%, titratable acidity from 5.48 to 42.91 mEq/100g, total polyphenol content from 718.19 to 2170.28 mg EAG/g and flavonoid content from 30.25 to 136.01 mg EQuer/g of dried onions. The results of the sensory analyses show that the steam-bleached and sun-dried samples were more appreciated by tasters for their color, taste and odor. Microbiological characteristics indicate the presence of aerobic mesophilic germs (1.30.10^1 to 7.06.10^5 CFU/g), total coliforms (5.80.10^1 CFU/g), yeasts and molds (1.10^1 to 1.81.10^1 CFU/g) and an absence of fecal coliforms, E. coli and ASR. All these results are an added value for onion processing and will help reduce post-harvest losses.

Keywords: Onion, drying, pre-treatment, high perishability, post-harvest losses, preservation

1. INTRODUCTION

The onion (Allium cepa L.), cultivated as a vegetable for its bulbs and leaves, is a monocotyledonous herbaceous plant in the Alliaceae family [1]. It is used as a condiment and is a basic ingredient in culinary preparations throughout the world [2]. It is one of the most widely marketed vegetables in the world. It is currently grown in over 170 countries. Global production is estimated at around 100 million tonnes in 2019. Africa and Côte d'Ivoire produced around 14 million tonnes and 8,602 tonnes respectively [3]. Although West Africa is full of success stories in terms of developing onion production basins, the industry is still marginal in Côte d'Ivoire, where 95% of onions consumed come from imports. However, its consumption in Côte d'Ivoire was estimated at over 200,000 tonnes in 2017 [3]. This high level of consumption stems from the dietary, nutritional and therapeutic virtues that onions abound in [2]. Nutritionally speaking, onions are considered an energy-giving, protective and supportive food. It contains vitamins such as B vitamins, vitamin C and provitamin A [4], as well as minerals such as potassium, sodium, zinc and iron, phosphorus, selenium,

magnesium, manganese, calcium [5], lipids, proteins, carbohydrates, essential oils, organic acids, fiber [6] and antioxidants [7]. Therapeutically, regular consumption of raw onions is thought to play a role in blood coagulation, the prevention of various pathologies (atherosclerosis, cataracts) and also in certain cardiovascular diseases and cancers [2]. Despite its nutritional and economic potential, and the interest shown in it by the population, the onion industry in Côte d'Ivoire faces enormous problems. Indeed, significant post-harvest losses are recorded in periods of abundance due to the high perishability of onions [8]. A recent study indicates that 21.5% of onions are lost during storage, with rotten bulbs representing the most significant loss (9.1%) [9]. The extent of these losses varies from one country to another, depending on the level of technology (temperature and humidity control around the preserved product) and the infrastructure of the storage facilities (controlled atmosphere chambers, etc.) [10]. Onion processing would therefore be a solution to reduce these post-harvest losses in periods of abundance. But it has to be said drying conditions have an influence on onion nutritional quality. In view of these losses, several studies have been carried out on the characterization and processing of onions in order to reduce post-harvest losses during periods of abundance. However, few studies have been carried out in Côte d'Ivoire on the nutritional characterization of drying methods, sun-drying at 33°C and shade-drying at 25°C of fresh onion bulbs for conservation purposes. It is therefore necessary to find drying conditions that will best reduce post-harvest losses and enhance production value. With this in mind, this study is being carried out to promote the use of two post-harvest preservation methods for fresh onion bulbs. The theme of this study is entitled 'the impact of blanching and two drying methods on the nutritional, organoleptic and microbiological properties of fresh onions of the Galmi violet variety sold on the KORHOGO markets'. The aim of this work is to contribute to the reduction of post-harvest losses of fresh onions, with a view to enhancing their value.

2. MATERIAL AND METHODS

2.1. MATERIAL

Samples Collection

Onions of the Galmi violet variety were purchased at the Korhogo large market. Batches of 3 kg fresh onions were purchased from five (5) different randomly selected traders. The fresh onion samples were then mixed to form a 15 kg (3 kg × 5) batch of purple onion and transported to the laboratory.

2.2. METHODS

2.2. 1.Transformation process

2.2.1.1. Pre-treatment of Violet de Galmi onions

Pre-treatment consisted of blanching the onions using two methods, immersion in boiling water for 5 minutes and steaming for 5 minutes. These methods were inspired by [11]. Onion bulbs were sorted and peeled using a stainless steel knife. The peeled onions were washed with tap water, drained for 10 min and then cut into slices less than 6 mm thick using knives. The onion slices obtained were then divided into three portions. The first portion served as a

control, while the second was blanched by steam cooking for 5 min. The third portion was pre-treated by immersion in boiling water for 5 min. At the end of the operation, the onion slices were drained through a stainless steel strainer for 15 min to remove surface water, and weighed before drying.

2.2.1.2. Sun-drying fresh onions

Sun-drying of sliced onions was carried out according to the method described by [12]. A mass of 1300 g of blanched fresh onion slices was spread successively on claires and sun-dried for 7 days, at a rate of 08 hours per day at a temperature of 33°C. The dried onion slices were then weighed and packed in polyethylene bags for subsequent analysis.

2.2.1.3. Shade drying of fresh onions

Shade drying of sliced fresh onion was carried out according to the method described by [13]. A mass of 1300 g of blanched fresh onion slices was spread out on a rack for 7 days in a ventilated room at an ambient temperature of 25°C. The dried onion slices were then weighed and packed in polyethylene bags for subsequent analysis.

2.2.2. Nutritive Properties

2.2.2.1. Proximate Analysis

pH and titratable acidity, ash, protein, lipid, and moisture content of fresh and dehydrated flour samples were determined using [14] method . To determine pH, 5 g of ground dried onion were placed in a 100 ml beaker, followed by the addition of 50 ml of distilled water. The mixture was homogenized using a magnetic stirrer. The pH meter electrode was submerged in the solution, and the pH of the solution was read directly on the display after a few seconds. The titratable acidity was assessed by titrating the produced solution with 0.1 N sodium hydroxide (NaOH) using phenolphthalein as a color indicator. To formulate the solution, 2 g of pulverized desiccated onion was incorporated into 20 ml of distilled water. The solution was filtered through a funnel onto Whatman paper. Two drops of phenolphthalein were introduced to 10 ml of the filtrate in a beaker. The solution underwent titration with a 0.1 N sodium hydroxide (NaOH) solution while being magnetically stirred. The titration concluded upon reaching the endpoint. This indicates the presence of a sustained pink hue in the solution. The moisture content was determined by the weight differential of a 10 g sample before and after drying in a Memmert oven (Germany) at 105°C until a consistent weight was achieved. Ash content was determined by the incineration of dried onion grind (5 g) in a muffle furnace (Pyrolabo, France) at 550°C for 12 h. The percentage residue weight was expressed as ash content. Nitrogen content was assessed using the Kjeldahl method, and the crude protein content was obtained by multiplying the nitrogen value by 6.25. The lipid content is ascertained using the Soxhlet technique.The fats are removed at the boiling point with pure hexane. The hexane is subsequently eliminated using evaporation, and the remaining residue is dried and weighed. Carbohydrates and calorific value were calculated using the following formulas [15].

Total Carbohydrates : 100 – (% moisture + % proteins + % lipids + % ash)

Calorific value : (% proteins x 4) + (% carbohydrates x 4) + (% lipids x 9)

The contents of ash, proteins, lipids and carbohydrates contents were expressed on dry matter basis.

2.2.2.2. Polyphenols determination

Phenolic compounds were first extracted in methanol using the method [16]. To this end, one gram of dried and ground onion was homogenized in 10 mL of 70% (v/v) methanol. The resulting mixture was centrifuged at 1000 rpm for 10 min. The pellet was recovered in 10 mL of 70% (v/v) ethanol and centrifuged again. The supernatants were collected in a 50 mL flask and made up to the mark with distilled water. The resulting solution was called methanolic extract. One mL of ethanolic extract was introduced into a test tube and 1 mL of 1/10th diluted Folin-ciocalteu reagent was added. The tube was left to stand for 3 min, then 1 mL of 20% (w/v) sodium carbonate solution was added. The contents of the tube were made up to 10 mL with distilled water and placed in the dark for 30 min. Optical density was read on a spectrophotometer at 725 nm against a blank. A standard range established from a stock solution of gallic acid (1 mg/mL) under the same conditions as the assay was used to determine the amount of phenols in the sample.

2.2.2.3. Flavonoid content determination

The technique employed to ascertain flavonoid content was that [17]. A volume of 0.5 mL methanolic extract was introduced into a test tube. To the contents of the tube were successively added 0.5 mL distilled water, 0.5 mL aluminum chloride, 0.5 mL potassium acetate and 2 mL distilled water. The tube was left to stand for 30 min in the dark, and the optical density (OD) was read at 415 nm against a blank. A calibration range carried out under the same conditions as the assay using a quercetin stock solution at 0.1 mg/mL was used to determine the flavonoid content of the samples.

2.2.3. Determination of organoleptic characteristics

Sensory analysis of the samples was carried out on dried onion slices using a hedonic test with a panel of 10 tasters. The dried onion samples were assessed by the panelists on the basis of quality attributes such as color, taste, odor and overall acceptability using the same procedure using a 5-point hedonic scale, with a variation from very pleasant (5) to very unpleasant (1) [18]. The sensory acceptability response variables were color, odor, taste and overall acceptability.

2.2.4. Microbiological analysis

To prepare the stock solution, 10 g of each sample was placed in a sterile stomacher bag, into which was added 90 ml sterile peptone water (5 g peptone, 8.5 g NaCl and 1000 ml distilled water, pH 7.0). The mixture was homogenized in a stomacher for 2 min at normal speed. From this stock suspension, a series of successive decimal dilutions was made for agar inoculation. Thus, 1 ml of solution was withdrawn using a micropipette and introduced into a tube containing 9 ml of diluent (sterile peptone water) at room temperature. Then, 1 ml of this mixture was again taken from the latter solution and introduced into the next tube containing the same quantity of peptone water. Dilutions were made up to the highest desired dilution. From these dilutions, aerobic mesophilic germs, total and faecal coliforms, yeasts and moulds, Escherichia coli and sulfuto-reducing anaerobic germs were tested and enumerated.

Aerobic mesophilic germ (AMG) was enumerated after incubation at 30°C for 72 h on Plate Count Agar (PCA, Oxoid, England) according to [19].

Total and fecal coliforms were enumerated according to [20] after plating, on crystal violet and neutral red bile lactose agar (VRBL, liofilchem, njnItaly). Incubation was carried out at 37°C for 24 h for total coliforms and 44°C for fecal coliforms.

[21] was used to enumerate yeasts and molds on Sabouraud chloramphenicol agar (liofilchem, Italy) after a 5-day incubation period at 25°C. Petri dishes containing fewer than 300 colonies were used to calculate the number of microorganisms present in the sample, expressed in CFU/g.

[22] was used for Escherichia coli enumeration on RAPID E. coli 2 agar after incubation at 44°C in less than 24 h.

Sulfuto reducing anaerobes (SRa) were counted in accordance with [23]. Inoculation was carried out on tryptone sulfite neomycin (TSN) medium, and petri dishes were incubated at 37 to 46°C for 24 h.

For each germ to be enumerated, inoculation was carried out using the mass inoculation method. 1 mL of each dilution was introduced into a sterile petri dish into which 15 mL of inoculum was poured in an aseptic zone at a temperature of 47°C in a water bath. The petri dishes were then homogenized. The dishes were left to solidify on the bench in the sterility zone before incubation in the oven. Calculation was made using colonies from two successive dilutions, using the formula below: $N= (\sum c)/((n_1+ 〚0,1.n〛 n_2)\times d)$.

2.3. Statistical analysis

All analyses were conducted in triplicate, and the results were analyzed using Excel. Analysis of Variance (ANOVA-1) and the Student-Newman-Keuls (SNK) test at the 5% significance level were employed to compare and distinguish means utilizing IBM SPSS Statistics version 20 software.

3. RESULTS AND DISCUSSION

3.1. Effects of pre-treatment and drying method on the biochemical quality of dried onions

Table I present the biochemical characteristics of onions of the Galmi violet variety pretreated and dried in sun and shade. Statistical analysis of the data indicates a significant difference in the values obtained for all the biochemical parameters evaluated between onion samples at $p < 0.05$ risk. The water content of the dried onion samples ranged from 14.49 to 16.99%, well below the 83.23% found in the fresh onion sample. The low amount of water after drying in the onion samples is not surprising, as drying involves reducing the amount of water by evaporation in the vegetables. According to [24], water reduction during drying varies from 1 - 55% in vegetables. Consequently, the lower water content in dried onion samples compared with fresh onions will enable dried onions to be preserved better by increasing dry matter [25]. Sun-dried, steam-pretreated and boiled-water-pretreated onion samples, respectively, had lower water contents (14.49% and 15.22%) than shade-dried, boiled-water-pretreated and steam-pretreated onion samples (16.68% and 16.99%). Sun-drying results in a greater reduction in water content in dried onion samples. As for pH, a

decrease was observed ranging from 4.01 to 4.48 for dried onion samples, compared with the pH of the fresh onion sample at 4.99. These acidic pH values found in this study could have a positive impact on the preservation of dried onion samples, reducing the growth of microorganisms. The acidic pH levels found in this study could have a positive impact on the preservation of dried onion samples, reducing the growth of microorganisms. Our results agree with those of [18], who found a pH of 4.01 for dried onion samples of the Galmi violet variety. This decrease in pH is coupled with an increase in titratable acidity. Values ranged from 32.62 and 42.91 mEq/100g for the dried onion samples, while the value for the fresh onion sample is 5.48 mEq/100g. The shade-dried onion sample (OBVSo) showed the highest acidity value (42.91 mEq/100g). This increase in acidity observed during the various drying processes is beneficial as it would limit the proliferation of microorganisms such as yeasts and molds in dried onions. Indeed, [26] reported in their study that the increase in acidity is due to the conversion of the sugar contained in the onion into organic acids. These results are similar to those of [26] and [18], who found an increase in acidity in dried onions. titratable after drying. The ash content of the fresh onion sample was 1.84%, while that of the dried samples ranged from 4.63 to 4.84%. The ash contents observed during the two drying processes show a significant difference. In fact, high ash contents were obtained with samples pretreated and dried in the shade, and low contents with those pretreated and dried in the sun. Ash content indicates the mineral content of a food. Therefore, its increase in onions during the different drying processes, and consequently that of the mineral content, could be due to the reduction of water which leads to an increase in dry matter in the different dried onion samples studied. The increase in ash content during onion drying corroborates reports by [27] and [28] that solar drying helps maintain more minerals in fruits and vegetables. The lipid content of sun- and shade-dried onions is higher than that of fresh onions. The high lipid content was observed in samples pre-treated with boiling water and steam then dried in the shade (6.17% and 6.39%) respectively versus those pre-treated with boiling water and steam then dried in the sun (3.41% and 3.52%) respectively. The results of this study are contrary to those of [29], who noted a decrease in lipid content from 145 mg/100g for fresh onions to 86.01 mg/100g and 98.84 mg/100g, when electrically air-dried and solar-dried respectively. This difference could be explained by the drying and pre-treatment methods used. Protein content varies from one drying method to another, with values ranging from 7.00 to 21.00% for dried onion samples. In contrast to onion samples boiled and then dried in the shade and in the sun, whose values range from (11.37% to 21.00%) respectively, onion samples pre-treated with steam and dried in the sun and in the shade fall (7.00% and 7.87%) respectively in relation to the onion's initial protein content. This difference could be explained by the different pre-treatment method. As for the total carbohydrate content, a strong increase is noted during both drying modes compared to fresh onion. The high carbohydrate content observed in the steam-treated and sun-dried onion sample is thought to play an important role in human health. Indeed, in addition to providing energy, carbohydrates are also required for many biochemical reactions not directly linked to energy metabolism. Our results are in agreement with those of [30], who observed in their study an increase in total carbohydrate contents ranging from 8.10 to 81.02g/100g after drying.

Table I: Biochemical characteristics of dried onions according to pre-treatment and drying method

Samples	Moisture content (%)	Ash content (%)	pH	Titratable acidity (mEq/100g)	Lipids content (%)	proteins content (%)	Total carbohydrate (%)	Calorific value (kcal/100g)
OFNS	83,23±0,085^{a}	1,84±0,040^{c}	4,99±0,051^{a}	5,48±0,588^{c}	2,90±0,000^{e}	10,50±0,000^{b}	1,52±0,045^{e}	74,20±0,180^{d}
OBBSs	15,22±0,040^{d}	4,70±0,100^{b}	4,23±0,020^{c}	33,12±0,611^{b}	3,41±0,015^{d}	21,00±0,875^{a}	55,66±0,720^{d}	337,39±0,485^{c}
OBVSs	14,49±0,035^{e}	4,63±0,030^{b}	4,01±0,045^{d}	41,93±1,613^{a}	3,52±0,020^{c}	7,00±0,000^{c}	70,35±0,015^{a}	341,10±0,120^{b}
OBBSo	16,68±0,001^{c}	4,81±0,010^{a}	4,48±0,030^{b}	32,62±1,020^{b}	6,17±0,025^{b}	11,37±0,875^{b}	60,95±0,865^{c}	344,89±0,185^{a}
OBVSo	16,99±0,065^{b}	4,84±0,040^{a}	4,01±0,047^{d}	42,91±0,617^{a}	6,39±0,005^{a}	7,87±0,875^{c}	63,89±0,905^{b}	344,63±0,075^{a}
F	953749,962	1790,41	309,581	726,239	32624,912	203,500	5582,487	668895,031
P	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Means with the same superscript letter in the same column are not significantly different at the 5% level. OBBSs: Onion Blanched in Boiling Water Dried in the Sun; OBVSs: Onion Blanched in Steam Dried in the Sun; OBBSo: Onion Blanched in Boiling Water Dried in the Shade; OBVSo: Onion Blanched in Steam Dried in the Shade; OFNs: Fresh Onion Undried.

The polyphenol and flavonoid compositions are shown in Figures 1 and 2 respectively. With regard to polyphenol content, an increase was observed during the drying process and according to the two pre-treatment modes compared with fresh onions. The phenolic content of the onion samples varied significantly according to the drying method. Values ranged from 2045.08 to 2170.28 mg EAG/g for shade-dried onion samples, and from 1326.56 to 1335.56 mg EAG/g for sun-dried samples. It should be noted, however, that shade-dried onion samples showed higher polyphenol contents than sun-dried samples. These results show that phenolic content was slightly influenced by drying conditions (drying temperature and pre-treatment). Overall, our results are superior to those obtained by [18], with polyphenol content ranging from 1.17±0.05 to 1.54±0.07 g/100g for the sun-dried Galmi violet variety. This difference is linked to drying conditions and pre-treatment. Indeed, a high drying temperature induces enzymatic degradation and irreversible oxidation of phenolic compound contents during drying [31]. In contrast, for the fresh onion sample 718.79±139.352mg EAG/100g, our results are similar to those reported by [32] who obtained 721.32±2.32 mg GAE/100g. The interest of phenolic compounds lies in their antioxidant properties. As a result, shade-dried onion samples have better antioxidant activity than sun-dried samples. Indeed, given their high antioxidant activity, shade-dried onion samples will be able to scavenge free radicals permanently generated by our bodies or formed in response to environmental aggression [33]. As for the flavonoid content of the phenolic compounds, the same variation was observed compared to the fresh state and according to the two drying methods. The high levels of flavonoids found in the shade-dried and steam-bleached onion sample (136.01mg EQuer/100g) are thought to help prevent certain chronic diseases, including inflammation, cardiovascular disease and cancer [34]. Indeed, [35] have shown that quercetin helps suppress the symptoms of diabetes. In addition, quercetin and kaempferol have been shown to be important contributors to infection control [36]. Consumption of vegetables rich in phenolic compounds is important, as they are highly effective in preventing the onset of some of these diseases. However, Our results are contrary to those of [29] who found a decrease in flavonoid content after drying of three varieties of onion powders. This difference would be linked to the variety, pre-treatment and drying environmental conditions.

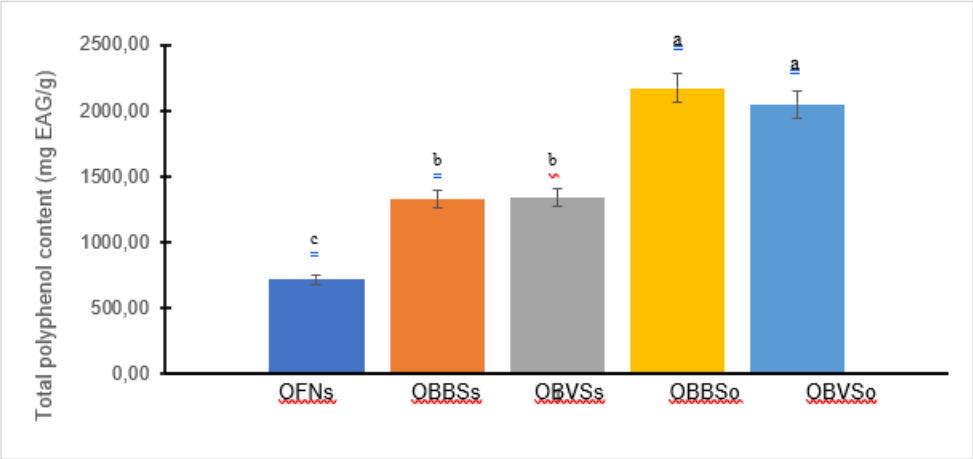

Figure 1: Diagram of total polyphenol content in fresh and dried onion samples as a function of pre-treatment and drying method

Non-identical letters indicate a significant difference at 5% risk. OBBSs: Onion Blanched in Boiling Water Dried in the Sun; OBVSs: Onion Blanched in Steam Dried in the Sun; OBBSo: Onion Blanched in Boiling Water Dried in the Shade; OBVSo: Onion Blanched in Steam Dried in the Shade; OFNs: Fresh Onion Undried

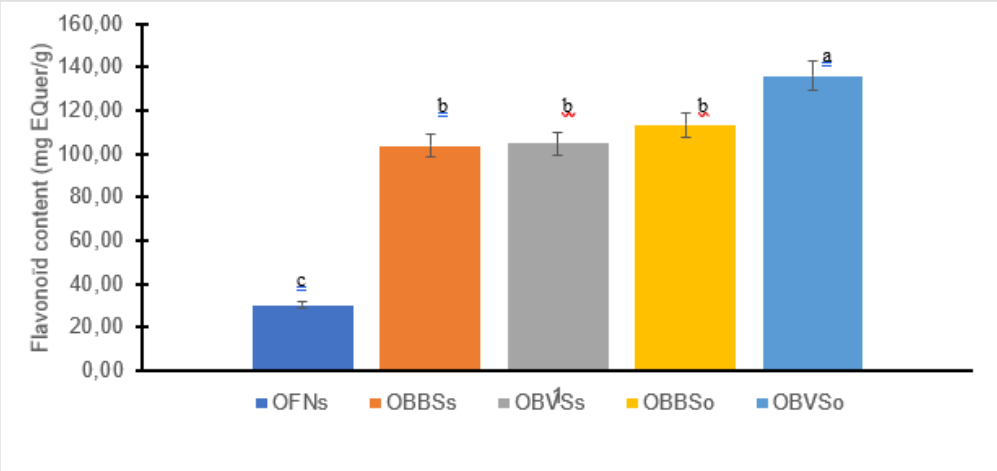

Figure 2: Diagram of Flavonoid content in fresh and dried onion samples as a function of pre-treatment and drying method

Non-identical letters indicate a significant difference at 5% risk. OBBSs: Onion Blanched in Boiling Water Dried in the Sun; OBVSs: Onion Blanched in Steam Dried in the Sun; OBBSo: Onion Blanched in Boiling Water Dried in the Shade; OBVSo: Onion Blanched in Steam Dried in the Shade; OFNs: Fresh Onion Undried

3.2. Effect of pre-treatment and drying method on organoleptic characteristics of dried violet de galmi onions

The assessment of color, smell, taste and overall acceptability of the dried onion samples is shown in figure 3. Analysis of the results revealed that 70% of panelists found the color of the onion samples blanched in steam and dried in the sun (OBVSs) and those blanched in boiling water and dried in the shade (OBBSo) pleasant. This good assessment could be explained by the presence of anthocyanin in the onions. Indeed, the presence of anthocyanin in onions induces the attractive coloring appreciated by consumers [37]. These results are lower than those of [18], who showed that 90% of tasters very much appreciated the color of dried onion samples. This difference could be explained by the drying temperature and the various pre-treatments carried out. As for the smell of the dried samples, 50% of tasters found the sun-dried steam-bleached (OBVSs), shade-dried boiled-bleached (OBBSo) and sun-dried steam-bleached (OBVSo) onion samples pleasant. This pleasant aroma is thought to be due to the presence of volatile oil containing sulfur Allyl-propyl-disulfide in the bulb [38]. In the same vein, [26] signified that aroma is conferred by volatile compounds and perceived by the odor receptor sites of the organ of smell. In fact, the pungency of the onion during preparation, processing and storage contributes significantly to the aroma of fresh and dried onions. As for the taste of the dried samples, analysis of the results shows that 60% of panelists found the samples of onions blanched in steam and dried in the sun (OBVSs) and those blanched in boiling water and dried in the shade (OBBSo) pleasant. Our results are similar to those of [39], who studied the improvement of onion drying technology and the formulation of seasoned condiments based on dried onion. The steam-bleached and sun-dried onion sample (OBVSs) stands out from the other samples due to its color, odor and taste. However, according to the sensory analysis of the onions from the four samples in the study, the panelists chose the sun-dried

steam blanched onion sample (OBVSs) as the favorite, followed by the shade-dried boiled blanched onion sample (OBBSo) and the sun-dried boiled blanched onion sample (OBBSs).

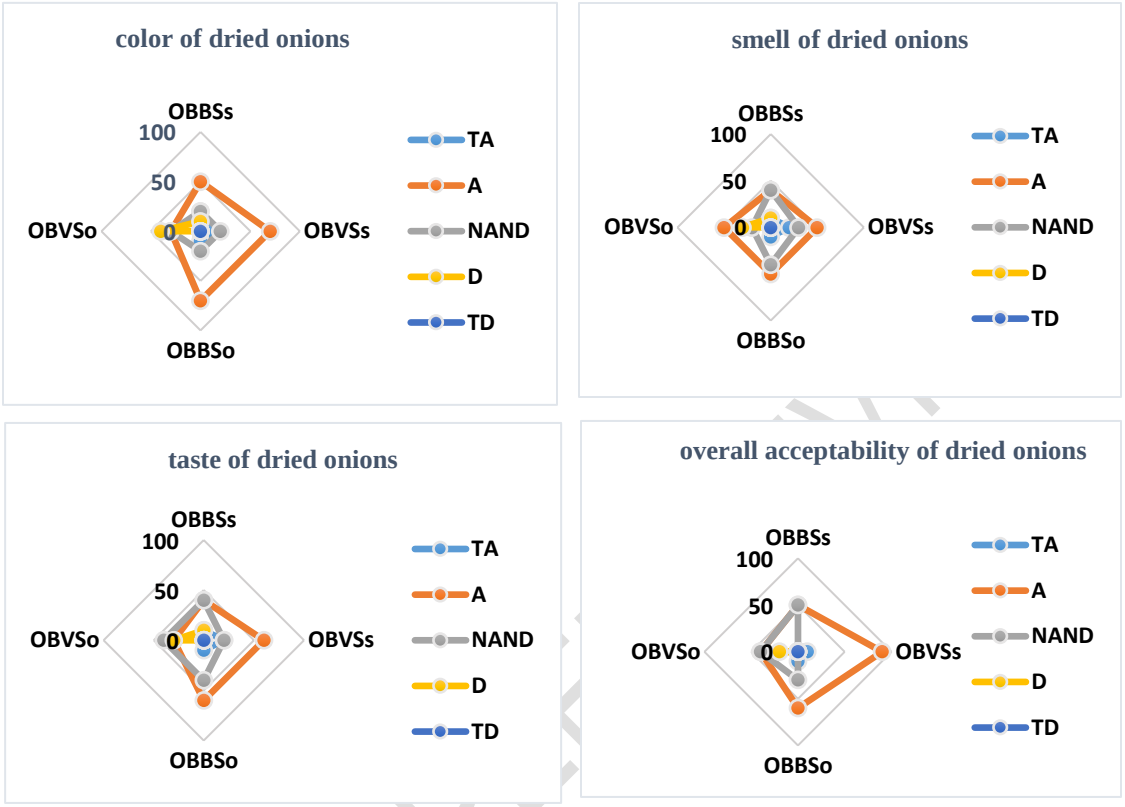

Figure 3: Evaluation of color, aroma, flavor, and general acceptability of dried onion samples

OBBSs: Onions blanched in boiling water and sun-dried; OBVSs: Onions blanched in steam and sun-dried; OBBSo: Onions blanched in boiling water and shade-dried; OBVSo: Onions blanched in steam and shade-dried;.**TD** : Very Unpleasant; **D** : Unplesant ; **NAND** : Non Pleasant Non Unpleasant; **A** : Pleasant ; **TA** : Very Pleasant

3.3. Effect of pre-treatment and drying method on Microbiological characteristics of dried violet de galmi onions

The results of the microbiological analysis of the dried onions are presented in Table 2. In contrast to the control (OFNs), which showed an absence of aerobic mesophilic germs, all dried onion samples showed a microbial load ranging from 1.30.101 CFU/g for shade-dried steam-bleached onion samples (OBVSo) to 7.06.105 CFU/g for sun-dried boiling water-bleached onion samples (OBBSs). These results are in line with the quality standards for dried products [40], which are 5.105 CFU/g to 5.106 CFU/g. The difference in GAM loading in onion samples during both drying modes could be due to contamination during packaging, drying or grinding. Our results are similar to those obtained by [39] who studied microbiological quality during the improvement of onion drying technology and formulation of seasoned condiments based on dried onion. As for yeasts and molds, microbiological analysis revealed their absence in samples of onions blanched with

steam and boiling water and then dried in the shade (OBVSo, OBBSo) and the control sample (OFNs) respectively. However, the presence of yeasts and molds was observed in samples of sun-dried steam-bleached onions (OBVSs) and sun-dried boiling water-bleached onions (OBBSs), with microbial loads ranging from 1.101 CFU/g to 1.81.101 CFU/g respectively. These results comply with the standard (102 CFU/g) set by [41], giving the product good manufacturing quality. With regard to total and faecal coliforms, with the exception of the onion sample blanched in boiling water and dried in the sun (OBBSs), which showed a microbial quantum of 5.80.101 CFU/g, an absence of microbial load in total and faecal coliforms was observed for all other samples. Despite the microbial load of total coliforms observed in the sample (OBBSs), it meets the quality standards for dried products, which are in the order of 102 to 103 CFU/g [42]. However, the total coliform load observed in the sample (OBBSs) is thought to be due to poor hygiene practices during processing and packaging. As for E. coli and ASR, analysis of the results indicates an absence of microbial load in all samples. These results comply with the standards (102 to 103 CFU/g) set by [41] for E. coli, and with [43], which are 103 to 104 CFU/g for RSA. The absence of these microorganisms would indicate good sanitary quality and the absence of fecal contamination in the samples.

Table 2: Microbiological characteristics of dried onions (CFU/g)

Samples	GAM (UFC/g)	Total coliforms (UFC/g)	Faecal coliforms (UFC/g)	E. coli (UFC/g)	ASR (UFC/g)	Yeasts and moulds (UFC/g)
OFNs	Absent	Absent	Absent	Absent	Absent	Absent
OBBSs	$7{,}06.10^{5}$	$5{,}80.10^{1}$	Absent	Absent	Absent	$1{,}81.10^{1}$
OBVSs	$6{,}96.10^{4}$	Absent	Absent	Absent	Absent	1.10^{1}
OBBSo	$1{,}53.10^{1}$	Absent	Absent	Absent	Absent	Absent
OBVSo	$1{,}30.10^{1}$	Absent	Absent	Absent	Absent	Absent

OBBSs : Onions blanched in boiling water and sun-dried; OBVSs: Onions blanched in steam and sun-dried; OBBSo: Onions blanched in boiling water and shade-dried; OBVSo: Onions blanched in steam and shade-dried;. Fresh onions that are not dried.

4. CONCLUSION

The results of this study showed that both sun- and shade-dried, pre-treated onion samples had good biochemical and nutritional properties compared with the OFNS control. However, both drying methods significantly reduced the water content in fresh onions. Blanching coupled with drying in the shade at around 25°C for 7 days better preserved the biochemical properties of dried onions. Onion samples pretreated and dried in the shade showed higher phenolic compound levels than those pretreated and sun-dried at 33°C for 7 days. Samples blanched with steam and dried in the sun (OBVSs) were the most appreciated by panelists, with the best organoleptic quality, followed by samples blanched with boiling water and dried in the shade (OBBSo). Microbiological analysis showed that the dried onion samples had a level of aerobic mesophilic germs, total coliforms, yeasts and molds in line with GMP standards. This is a factor in product quality. Sliced, pre-treated and dried onions have a long shelf life and good nutritional, organoleptic and microbiological properties. This processing method could therefore be an alternative to reduce post-harvest onion losses in periods of abundance.

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