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EVALUATION OF THREE DRYING TECHNIQUES FOR EXTENDING THE SHELF LIFE OF ONIONS

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ABSTRACT

This study aimed to evaluate three drying techniques: solar drying, electric drying, and oven drying, to extend the shelf life of onions. The results showed that carbohydrate content increased for all three drying methods (6.08% to 84.33%). Vitamin C decreased during solar drying (6.07 mg to 4.43 mg), while it increased for the other two drying methods (28.3 mg for oven drying and 38.3 mg for electric drying). Acceptability testing indicated that samples obtained through electric drying were the most preferred with a rating of 7. Onions dried in the oven received a rating of 6, while those dried using solar drying were the least preferred with a rating of 5.

Keywords: Onions, Drying technique, Conservation time

INTRODUCTION

The onion, scientifically known as Allium cepa L, is a monocotyledonous plant native to Central Asia (Pitrat et Foury, 2003). For over 5000 years, it has been cultivated as a vegetable for its bulbs and leaves (DDI, 2007). It holds a crucial place in the cuisine of all regions as a fundamental ingredient (Mégroz et Baumgartner, 2000). In Africa, Nigeria and Niger stand out as the main onion producers (Currah, 2002). In Côte d'Ivoire, onion production is still modest, covering only 5% of the estimated national demand of 120,000 tons per year. The remaining 95% is imported from countries such as Burkina Faso, Mali, Niger, the Netherlands, Thailand, and Egypt (Anonyme 1, 2021). Onions are widely recognized for their exceptional nutritional value in many regions (Abdoulaye, 2011). Several studies have shown the presence of mineral salts and phenolic compounds in onions (Singh et al., 2009; Perez-Gregorio et al., 2010 ; Cheng et al., 2013). It is also rich in phenolic substances due to its high flavonoid content (Bystrická et al., 2013). Furthermore, onions contain a significant amount of vitamin C (7.4 mg/100g) and are a good source of carbohydrates (Abdoulaye, 2011). However, despite its numerous nutritional benefits, onions are subject to significant post-harvest losses during periods of abundance due to their high-water content (89.11 g per 100g), making them highly perishable (Onwude et al., 2017). To address this issue, transformation initiatives are being implemented, primarily focusing on drying methods (FAPASP, 2011). In this context, our work aims to optimize onion drying technology by comparing three main drying techniques to extend its shelf life.

1. MATERIALS AND METHODS

1.1. Biological material

The biological material used in this study mainly consists of bulbs from the purple variety of Galmi onions, which are widely consumed in Côte d'Ivoire according to the (CNLVC, 2017). The bulbs were purchased from three different vendors in three different markets and were transported to the experimental site where the various drying activities were carried out.

1.2. Sampling

Sampling was conducted in Côte d'Ivoire in the month of April. A total of 15 kg of Galmi purple variety onions were purchased from three wholesalers, with 5 kg from Yopougon Toits Rouge market, 5 kg from Bouaké market, and 5 kg from the main Adjamé market. These onions were then transported to the laboratory of the National Center for Floristics (CNF) mushroom farm to undergo an improved drying process using a solar box dryer and an electric dryer. They were then directed to the biochemistry laboratory for incubation. At the laboratory, the onions were sorted, washed with tap water, and cut into slices with a thickness ranging from 1.5 to 2 cm. Before being subjected to the different drying techniques, they were pre- treated. The onions were divided into 4 equal-sized batches (3 kg per batch) for the different drying techniques while retaining 3 kg of fresh onions for biochemical analysis.

1.3. Pre-treatment of onions before drying

The onion bulbs (Galmi purple variety) were pre-treated according to the method described by AKOHA (2021). Twelve kilograms of sorted and peeled bulbs were washed with tap water and drained for 10 minutes. Then, the bulbs were manually cut into slices with a thickness ranging from 1.5 to 2 cm using knives. The obtained slices were divided into four portions. The first portion was left as it is, constituting the control group. The second portion was pre- treated by immersion in saltwater containing 5% salt for 10 minutes, while the third and fourth portions were subjected to blanching, respectively by steaming in 5% saltwater and boiling water vapor for 10 minutes. After each pre-treatment, the onion slices were drained using a stainless-steel strainer for 15 minutes to remove excess surface moisture. Finally, the onion slices were weighed before undergoing the drying process.

1.4. Drying

The different drying techniques studied are oven drying, electric drying, and solar drying in a box. Oven drying and electric dryer allowed drying the onions at constant temperatures of 50°C and 47°C respectively. As for solar drying, it was done in a box dryer, offering the advantage of protecting the products from insects and dust, unlike traditional open-air drying which is subject to weather conditions. The energy used by the electric dryer was provided by a 100W bulb. The samples of Galmi Purple variety onions were dried and then packaged in stomacher bags for biochemical analysis. The samples from different treatment stages and three types of drying were stored for three months. The stability of dried onions was studied every month.

1.5. Determination of biochemical parameters of dried onion

1.5.1. Protein content determination

The crude protein content is determined based on nitrogen content using the Kjeldahl method (AOAC, 1990). It involves a mineralization phase, followed by distillation and titration with sulfuric acid in the presence of a colored indicator. First, a mass of 1 g of vegetable is weighed into a mineralization flask to which catalysts (selenium, copper sulfate (CuSO4), potassium sulfate (K2SO4)), and 20 mL of concentrated sulfuric acid are added. Mineralization is carried out at 400°C for 2 hours in a digester. The resulting mineralized sample is cooled to room temperature, transferred to a 100 mL flask, and completed with distilled water. After starting the distillation apparatus, 10 mL of the mineralized sample is taken and mixed with 10 mL of NaOH (40%). The mixture is placed in the distillation reservoir. The condenser tube is immersed in a beaker containing 20 mL of boric acid solution (4%) with a mixed indicator (methyl red + bromocresol green): the solution turns purple. Distillation is carried out for 10 minutes. At the end of distillation, the solution turns green. The protein content relative to dry matter is determined using the following formula:

$$\frac{(V_1 - V_0) \times 14 \times 6{,}5 \times N}{M_e} \times 100$$

V_0: Volume (mL) of sulfuric acid solution used for blank test
V_1: Volume (mL) of sulfuric acid solution used for sample test
N: Normality of sulfuric acid solution (0.1) Me: Mass (g) of the sample
6.25: Conversion factor from nitrogen to protein

1.5.2. Lipid content determination

The fat content was analyzed using the Soxhlet method according to AFNOR guidelines (1986). This method involves dissolving the fats from a food sample in an organic solvent, followed by evaporation of the solvent to recover the fats. For this analysis, 10 g of ground sample (m0) were placed in a pre-weighed cellulose extraction cartridge. The cartridge was sealed with cotton and inserted into a Soxhlet-type extractor. Total lipids were extracted using 300 ml of refluxing hexane for 7 hours. Then, the hexane was evaporated using a rotary evaporator. The extraction flask, previously weighed empty (m1), was dried at 100 °C for 20 minutes. The entire set (flask + fat) was weighed (m2). The fat content (MG) was calculated as a percentage of the mass of the dry sample (dry matter) using the following formula:

$Proteins/DM$

$$MG\ (\%) = \frac{M2 - M1}{M0} \times 100$$

DM: Dry matter

m_0: mass of the initial sample (g)

m_1: mass of the empty extraction flask (g)

m_2: mass of the combined (flask + fat) after drying in the oven (g)

1.5.3. Carbohydrate content determination

The total carbohydrate content relative to dry matter was determined using a differential method. The calculation is done using the determined values of protein, lipid, ash, and moisture levels. The formula used is as follows:

%Total carbohydrates/DM = 100 - %C/DM
+%P/DM + %L/DM

%P/DM = Percentage of protein relative to dry matter

%L/DM = Percentage of lipid relative to dry matter

%C/DM = Percentage of ash relative to dry matter.

1.5.4. Determining phenolic compound content

The Folin-Ciocalteu method (Singleton et al., 1999) was used to determine the phenolic compound content. 5g of each sample of dried onion powder were diluted in 50 ml of 70% methanol and filtered using Whatman paper. This solution (0.5 ml) was mixed with 2.5 ml of Folin-Ciocalteu reagent (0.2 N) for 5 min, and then 2 ml of 75g/l sodium carbonate (Na_2CO_3) were added. After incubating at room temperature for 2 hours, the absorbance of the reaction mixture was measured at 760 nm against a 70% methanol

1.5.5. Determining mineral content: calcium, magnesium, sodium

The mineral ions were measured in three steps: incineration, extraction, and actual measurement. The ashes obtained after incineration were dissolved in 100 mL of distilled water under magnetic stirring for 30 minutes. The resulting solution was filtered using Whatman No.1 paper, and the filtrate was used for the measurement of different mineral ions by ion chromatography. This analytical technique allows for qualitative (separation of present species) and quantitative analysis of ionic species in a liquid sample free from suspended matter.

1.5.6. Determining vitamin C content

The method used for measuring the vitamin C content of the samples was described by Pongracz et al. (1971), based on the reduction of 2,6 DCPIP (2,6 dichlorophenol- indophenol). A quantity of 10 g of ground sample was dissolved in 40 mL of metaphosphoric acid-acetic acid (2%; w/v). The resulting mixture was centrifuged at 3000 rpm for 20 minutes. The supernatant was transferred to a 50 mL volumetric flask and adjusted with boiled and cooled distilled water under air exclusion. A 10 mL aliquot was titrated with 0.5 g/L 2,6 DCPIP in an Erlenmeyer flask until a persistent pink color change occurred. The vitamin C content of the sample was determined using the following expression:

$$Vitamin\ C\ (mg\ 100\ g) = \frac{C_{2,6\ DCPIP} \times V_e \times 5}{P_e}$$

blank using a spectrophotometer. Gallic acid (0-200mg/l) was used as a standard, and the total phenolic content is expressed in mg of gallic acid/100 g of powder.

Ve: volume of 2,6-dichlorophenol indophenol obtained from titration of the filtrate
C2,6DCPIP: concentration of dichlorophenol indophenol (0.5 g/L)
Pe: sample aliquot

1.5.7. Determining organoleptic characteristics

Dried onions were subjected to an acceptability test following the method described by Boutrolle (2009) to assess their level of appreciation. The panel consisted of 30 untrained individuals, including young female and male students at Felix Houphouet-Boigny University in Cocody, recruited based on their availability. The different evaluated criteria included taste, color, texture, odor, and overall acceptability of the samples. The samples were served in disposable coded plates with three random digits, according to the coding table, and presented simultaneously to the panel members. Taste satisfaction was assessed using a 9-point hedonic scale, following the method of Meilgaard et al. (1999). The tasters evaluated these attributes for each individual sample, providing data on the sensory perception of dried onion slices.

1.5.8. Statistical analysis

Three trials were conducted for each parameter studied. The statistical analysis of the results for physicochemical and biochemical parameters, as well as the acceptability test, was performed using STATISTICA 10.1 software. To determine significant differences, a Tukey test with a significance level of α=0.05 was conducted.

Graphical representation of the different tests was done using Excel software.

2. RESULTS

2.1. Biochemical characteristics of fresh onions and dried onions

The biochemical parameters evaluated in this study include protein, lipid, carbohydrate, and polyphenol levels (Table I), as well as mineral contents such as sodium, calcium, magnesium, and vitamin C in fresh and dried onions, as presented in Tables I and II. In general, the results of the statistical tests show differences for certain parameters studied, such as carbohydrate, mineral, and vitamin C levels ($p > 0.05$), while protein, lipid, and polyphenol levels show no significant statistical difference ($p < 0.05$).

Regarding carbohydrate levels, values increased relative to fresh onions for all three drying methods, ranging from 6.08% for fresh onions to values between 77.93% and 84.33% for dried onions. As for the studied minerals, compared to fresh onions, there was a slight decrease in magnesium and calcium levels, while sodium levels increased for some samples. Vitamin C content in fresh onions (6.07 mg) decreased during sun drying (4.43 mg), while for the other two drying methods, vitamin C increased to 28.3 mg for oven drying and 38.3 mg for electric dryer-dried onion samples. On the other hand, lipid levels (ranging from 0.77% to 1.25%), protein levels (ranging from 5.28% to 6.27%), and polyphenol levels (ranging from 7.26% to 7.36%) were similar to those of fresh onions for these parameters (1.01% for lipids, 5.7% for proteins, and 7.34% for polyphenols), and no significant difference was observed ($P < 0.05$). Overall, the electric dryer yielded better biochemical results compared to the other two drying methods used.

Table I: Lipid, protein, carbohydrate, and polyphenol content of onions dried by drying method.

TYPE OF DRYING	LIPID (%)	PROTEIN (%)	CARBOHYDRATE (%)	POLYPHENOL (%)
Solar drying	0,77±0,19 ^{a}	5,28±0,89^{a}	77,93±3,01^{c}	7,26±0,35^{a}
Oven drying	1,03±0,30^{a}	6,13±0,05^{a}	77,91±4,96^{c}	7,34 ±0,35^{a}
Electric drying	1,25±0,25^{a}	6,27±0,60^{a}	84,33±2,26^{b}	7,36±0,35^{a}
Fresh onion	1,01±0,12^{a}	5,7±0,01^{a}	6,08±0,02^{a}	7,34±0,01^{a}

Table II: Calcium, magnesium, sodium, and vitamin C content by drying method.

TYPE OF DRYING	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	SODIUM (mg/kg)	VITAMIN C (mg)
Solar drying	238,1±0,54^{b}	122,57±0,22^{b}	488,7±0,34^{a}	4,43±0,44^{c}
Oven drying	244,2±0,02^{b}	163,1±0,17^{b}	561,8±0,19^{b}	26,3±0,07^{b}
Electric drying	302,3±0,01^{a}	214,5±0,17^{a}	651,3±0,17^{b}	38,3±0,05^{b}
Fresh onion	456,9±0,32^{a}	230,5±0,27^{a}	335,2±0,38^{a}	6,07±0,34^{a}

2.2. Comparisons of different drying techniques

Onions dried using the solar dryer, exposed to a temperature range of 65°C to 70°C, were dried in less than two days. As for the other two methods, namely oven drying and electric dryer, they allowed onions to be dried at constant temperatures of 50°C and 47°C respectively. Although the temperatures used were relatively close, onions dried in the oven required about 20 hours to reach their optimal drying state, while those dried in the electric dryer reached this stage in just 8 hours. It is important to note that after three months of storage, samples dried with the electric dryer maintained stable physicochemical values, unlike those dried by sun drying and oven drying, which showed variations (Table III).

Table III: Evolution of physicochemical characteristics of onion stored for 3 months.

	Month 1			Month 2			Month 3		
Type of drying	**pH**	**Water content**	**Acidity (meq /100g)**	**pH**	**Water content**	**Acidity (meq /100g)**	**pH**	**Water content**	**Acidity (meq /100g)**
Solar drying	4,39 ±0,01[b]	8,91 ±0,32[c]	30,89 ±0,12[c]	4,58 ±0,19[b]	9,01 ±0,22[c]	31,81 ±0,55[c]	4,82 ±0,03[a]	9,14 ±0,24[c]	30,89 ±0,47[c]
Oven drying	4,86 ±0,21[a]	8,81 ±0,33[c]	31,67 ±0,15[b]	4,92 ±0,34[b]	8,91 ±0,17[c]	32,09 ±0,42[c]	5,19 ±0,01[a]	9,01 ±0,15[c]	31,67 ±0,32[c]
Electric drying	5,11 ±0,05[a]	8,47 ±0,37[b]	33,65 ±0,29[b]	5,12 ±0,01[a]	8,49 ±0,26[b]	33,65 ±0,21[b]	5,23 ±0,02[a]	8,51 ±0,11[b]	33,65 ±0,27 [b]
Fresh onion (FO)	5,25 ±0,01[a]	88,71 ±0,01[a]	6,32 ±0,01[a]	5,25 ±0,01[a]	88,71 ±0,01[a]	6,32 ±0,01[a]	5,25 ±0,01[a]	88,71 ±0,01[a]	6,32 ±0,01[a]

2.3. Acceptability test

The overall evaluation of the acceptability of dried onions revealed that only samples of onions dried using the electric dryer and oven dryer were particularly well-liked. On the other hand, onions dried in the box dryer received lower appreciation. Statistical results generally showed significant differences, regardless of the type of dryer used, for all samples, whether they were treated or not ($p>0.05$).

On average, based on the type of dryer, samples dried with the electric dryer were most preferred by the tasters, receiving a score of 7, corresponding to a moderately high level of satisfaction. Onions dried in the oven received a score of 6, corresponding to a slightly high level of satisfaction. Samples of onions dried with the electric dryer and oven dryer stood out from other samples due to their color, texture, smell, and taste. Furthermore, samples of onions dried in the solar box dryer were perceived on average as having an unpleasant taste but a good smell and acceptable texture. The most appreciated color in this sample was that of the sample treated by immersion in salt, as the other samples had a brown hue (Figure 1).

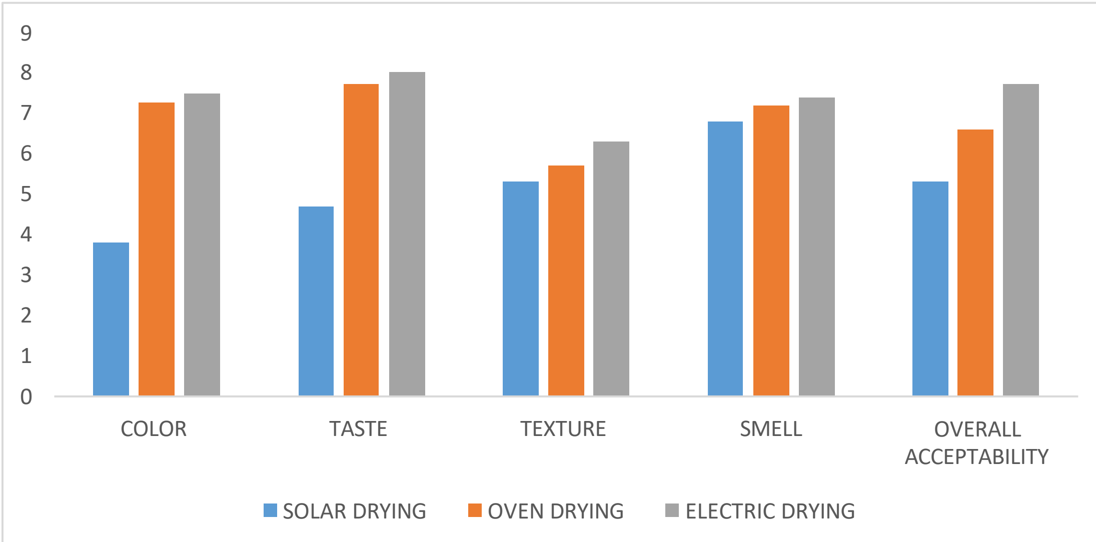

Figure 1: Graph of the acceptability test of dried onions based on the drying method.

3. DISCUSSION

Protein, lipid, and polyphenol contents did not show significant differences after drying, suggesting that drying did not have a negative effect on these parameters. In fact, the protein and lipid values obtained after drying are close to the nutritional reference values for dried onions provided by CIQUAL (2017). However, significant differences were observed in other biochemical parameters such as carbohydrates, minerals, and vitamin C. Carbohydrate levels varied depending on the drying method due to water loss during the process, resulting in the concentration of certain substances, including sugars. These high carbohydrate concentrations gave the dried onion slices a sweet taste as shown in Belem et al. (2017) study on dried mangoes.

Regarding minerals, calcium and magnesium decreased in dried onions compared to fresh onions, while sodium increased, likely due to pre-treatment with NaCl. The calcium values for the solar dryer and oven dryer were lower than the nutritional reference values for dried onions, unlike the electric dryer. However, the sodium and magnesium values obtained from the different drying methods were higher than the values provided by CIQUAL (2017).

The vitamin C content significantly decreased ($P < 0.05$) in onions dried at temperatures above 65°C due to heat sensitivity (Verma et al., 2020). Onions dried using electric drying had higher vitamin C content compared to other drying methods (38.3 mg versus 26.3 mg and 4.43 mg for oven and solar dryers).

In terms of sensory evaluation, onions dried in the oven at 50°C and those dried in the electric dryer at 47°C were well accepted, however, those dried in the electric dryer at 47°C were preferred over others. Maillard reactions related to high temperatures may explain the darker color of onions dried in the solar dryer at a temperature above 65°C, consistent with the findings of Machiels and Istassse (2002).

Furthermore, it is important to note that there was no significant change for the different measured parameters, especially for those dried in the electric dryer, even after three months of storage. Additionally, onions dried in the electric dryer maintained their initial appearance after these three months of storage.

CONCLUSION

The results obtained revealed that two out of the three drying methods tested significantly improved the physicochemical, biochemical, and sensory characteristics of dried onions, particularly their sugar content. These two methods were oven drying and electric drying. However, electric drying proved to be the most effective method as it not only preserved the nutritional compounds of dried onions but also maintained their initial appearance after three months of storage. It is important to note that the temperature and drying time were optimal in the case of electric drying, allowing for drying in just 8 hours at a temperature of 47°C. This drying method successfully reduced the moisture content of fresh onions, thus slowing down their deterioration and extending their shelf life compared to other drying methods used. Sensory tests showed that onions dried using this improved technology were well accepted in terms of taste, texture, color, and odor, preserving their sensory appeal.

The use of this improved drying technology appears promising in extending the shelf life of bulb onions while preserving their physicochemical, biochemical, and sensory characteristics. Therefore, it is worthwhile to promote and encourage the use of electric drying technique for onion preservation and expand its application to other perishable vegetables.

REFERENCES

Abdoulaye, J. M. 2011.: Evaluation de la valeur nutritive et des vertus thérapeutique de l'oignon : Cas du quartier Koirategui. Institut de Sante Publique – Nutrition humaine.

AFNOR. 1986. Recueil de normes françaises. Contrôle de la qualité des produits laitiers. Afnor, Paris-la-Défense.

AKOHA P. 2021. Influence de deux techniques de séchage sur la qualité de deux variétés d'oignons séchés et conservés à l'échelle pilote au sud du bénin. Mémoire de master professionnel, université d'ABOMEY-CALAVI, 56p

Anonyme 1, 2021 : https://www.fratmat.info/article/211858/con omie/filiere-oignon-la-cotedivoire-produit- moins-de-5-de-sa-consommation Consulté le 10 juin 2022

AOAC. 1990. Official Methods of Analysis. 15*th* Edition, Washington District Colombia., pp: 375-379.

Belem A., Tapsoba F., Songre-Ouattara L. T., Zongo C. & Savadogo. 2017. Study of the organoleptic quality of three varieties of dried mangos: Amélie, Lippens and Brooks during storage by enzymatic tanning technique of peroxidases (POD) and the polyphenoloxydases (PPO). *Revue des sciences et de la technologie* **34**: 38-47.

Boutrolle I. 2009. Mesure de l'appréciation des aliments des aliments par des consommateurs: état des pratiques et propositions méthodologique. Thèse de doctorat en sciences alimentaires, Institut national agronomique ParisGrignon, France, 301p.

Bystrická J. et al., Musilová. J., Vollmannová. A., Timoracká. M. 2013. Bioactive components of onion (Allium cepa).

Cheng A., Chen X., Jin Q., Wang W., Shi J.; 2013. Comparison of phenolic content and antioxidant capacity of red and yellow onions. Czech J. Food Sci. 31, 501-508.

CIQUAL, Ciqual Table de compositon nutritionelle des aliments. 2017. En ligne: https: ciqual.anse.fr consulté le: 03-JUIN- 2023.

CNLVC, 2017: Conseil National de Lutte contre la Vie Chère, cnlvc.ci/2017/07/03/fruit-de-passion/

Currah L.; 2002. Onions in the Tropics: Cultivars and Country Reports. Int: Rabinowitch H.D. and Currah L., eds. Allium Crop Science: Recent advances, Wallingford, Oxon, UK: CABI Publishing, New York, USA, 379-408.

DDI, 2007. Fiche technique pour la production de l'oignon au Burkina Faso, 10p.

FAPASP, 2011. Compte rendu de l'atelier nationale du bilan de la campagne 2009-2010 et programmation 2010-2011, de la filière oignon dans la zone d'intervention du FAPASP. 84p. http://www.pafasp.org/oignon. Consulté le 14 mai 2022

Machiels D. & Istasse L. 2002. La réaction de maillard: importance et applications en chimie des aliments. *Annales de médecine Vétérinaire,* **146:** 347-352.

Mégroz N, Andreas Baumgartner ASA; 2000. L'oignon, bon au goût et à l'œil. A la loupe, tabula no 2. Avril 2000, 4. Meilgaard M. C., Civille, G. V. & Carr

B.T. 1999. Sensory evaluation techniques, 3rd Edition. CRC. CRC Press, London. 441p.

Onwude D.I., N. Hashim, R. Janius, K. Abdan, G. Chen, A.O. Oladejo; 2017. Non- thermal hybrid drying of fruits and vegetables: a review of current technologies Innov. Food Sci. Emerg. Technol., 43, pp. 223-238.

Perez-Gregorio, R.M., García-Falcon, M.S., Simal-Gandara, J., Rodrigues, A.S., Almeida, D.P.F.; 2010. Identification and quantification of flavonoids in traditional cultivars of red and white onions at harvest. J. Food Compos. Anal. 23, 592–598**.**

Pitrat M, Foury C. 2003. Histoires de légumes; Des Origines à l'orée du XXIe siècle. INRA: Paris; p: 111.

Pongracz G., weiser H. & Matzinger D. 1971. Tocopherols-Antioxydant. Fat. *Sciences. Technology*, **97**, 90-104. Singh, B.N.,Singh, B.R., Singh, R.L.,

Prakash, D., Singh, D.P., Sarma, B.K., Upadhyay, G., Singh, H.B.; 2009. Polyphenolics from various extracts/fractions of red onion (Allium cepa) peel with potent antioxidant and antimutagenic activities. Food Chem. Toxicol. 47, 1161– 1167.

Singleton V. L., Orthofer R. & Lamuela- Raventos R. M. 1999. Analysis of total phenols and other oxidant substrates and antioxidants by means of Folin-Ciocalteu reagent. Methods in Enzymology, 299, 152-178.

Verma D. K., Thakur M., Srivastav P. P., Karizaki V. M., & Suleria R. A.H. 2020. Effects of Drying Technology on Physiochemical and Nutritional Quality of Fruits and Vegetables. Enligne: https://www.researchgate.net/publication/34 1192403