Journal of Dietitians Association of Nigeria (JDAN) Volume 12. December, 2021 Print ISSN: 2141-8209; eISSN: 2635-3326
Available online at: www.jdan.org.ng; https://www.ajol.info/index.php/jdan/index
DOI: https://dx.doi.org/10.4314/jdan.v12i1.7

NUTRIENTS AND ANTIOXIDANT PROPERTIES OF RED, YELLOW AND WHITE ONIONS (*Allium cepa* L) IN IBADAN, OYO STATE, NIGERIA

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ABSTRACT
Background: Onions is the most widely consumed vegetable worldwide and is a rich source of phytochemicals and antioxidants responsible for fighting free radicals in the body and preventing diseases
Objective: The general objective of the study was to analyze and compare the nutrient and antioxidant properties of red, yellow and white onions in Oyo state, Nigeria.
Materials and Methods: The research design was experimental. Samples were analyzed chemically according to the official method of analysis described by the Association of Official Analytical Chemist (AOAC). All analysis was carried out in triplicate. Data was analyzed using IBM SPSS statistics version 20. ANOVA was used to compare different variables together.
Results: The protein content was same in red and white onions. The crude fibre for red onions was 1.1 ±0.12, yellow onions 1.4±0.08 and white onions 1.2 ±0.12. White Onions had the highest total ash content (0.8 ±0.08), followed by yellow onions (0.6 ± 0.08) and red onions (0.6 ±0.05). The carbohydrate (by difference) was 12.2 ±0.09 for red onions, 11.1 ±0.22 for yellow onions and 11.4 ±0.36 for white onions. The reducing sugars for red onions was 1.8 ±0.12, yellow onions had 1.1 ±0.08 while white onions contained 1.2 ±0.12. The total sugars for red onions, yellow and white onions were 2.6 ±0.12, 1.7 ±0.12 and 2.2 ±0.12 respectively. The ascorbic acid (mg/100g) content was 15.8 ± 0.79 for red onions, 11.2 ±0.21 for yellow onions and 12.4 ±0.53 for white onions. Quercetin (mg/g) was highest in red onions (0.32 ±0.02), followed by yellow onions (0.24 ±0.01) and then white onions (0.19±0.01).
Conclusion: The nutrients and antioxidant (quercetin and vitamin c) properties were higher in red onions compared to the other varieties (white and yellow) of onions.

Key words: *Nutrients, Antioxidant, Red Onions, Yellow Onions, White Onions*

INTRODUCTION
Onion (Allium cepa L.) is a very important agricultural economic crop that is widely planted around the world and it is also one of the most cultivated and consumed vegetable. People give great importance to the health function of vegetables because of the abundant flavonoid content and the beneficial effects of nutritious antioxidant present in them (1,2,3). Onions come in three different of colours which are red, yellow and white; primarily due to anthocyanins in the epidermal cells of the scale leaves of the bulb (4). Anthocyanin is a group of natural plant pigments that is widely distributed in vegetables including onion which help to prevent neuronal diseases, cardiovascular illnesses, cancer, diabetes, inflammation and many other diseases (4). In Nigeria, onion is grown mostly in Northern states like Kano, Kaduna, Jigawa, Sokoto, Plateau, Bauchi, and Kebbi state. It is one of the most consumed and sold vegetable in Nigeria with, the most common type being the red onion (5).

The consumption of vegetables like onions has been shown to be associated with the reduced risk for the development of chronic diseases, such as cancer because of the presence of quercetin and cardiovascular diseases because of the antioxidants present in onions (6). Phytochemicals, including phenolics and flavonoids, are the major bioactive compounds contributing to the health benefits of onions. Onions are a major source of dietary flavonoids - a large and diverse group of polyphenolic compounds with antioxidant effects, and onion is one of the richest sources (7). However, varietal differences may exist in the composition, concentration, and beneficial activities depending on the cultivation conditions (8). Onion can be consumed in its raw, processed and stored state. The interest in the potential health benefits of allium vegetables, onion in particular, has its origin in antiquity (9).

Some researches carried out on onions include works by Edet *et al.* (10) on anti-nutrient composition and mineral analysis of cepa in Akwa Obom State, nutrient content variation in bulb and stalk of onions by Yahaya *et al.* (11) in Kebbi State, proximate content and elemental evaluations of Allium cepa linn by Osuji *et al.* (12) in Borno State and a review by Nassarawa and Suleiman (13) on extending the shelf life of onion and tomato in Nigeria. Cheng *et al.* (14) conducted a study comparing the phenolic content and antioxidant capacity of red and yellow onions. The results showed that the red variety showed better antioxidant activity than yellow onion. Lenkova *et al.* (15) also compared the content of total

DOI: https://dx.doi.org/10.4314/jdan.v12i1.7

polyphenols and antioxidant activity of selected species of the genus Allium. Their results showed that the value of antioxidant activity ranged from 12.29 – 76.57%. Red onions had the highest antioxidant activity after chives and ransom, then followed by yellow and white onions (15). No research has been carried out in the study area to show the nutrients and antioxidant content of onions. Onions of various colours and flavours are available in the market and consumers are now more health oriented and aware of healthy eating habits and therefore, pay attention to the appearance, nutritional prophylactic and medicinal values of onions (19). This study therefore analyzed and compared the nutrient and antioxidant properties (including quercetin) in red, yellow and white onions in Oyo state, Nigeria.

MATERIALS AND METHODS

Source of materials

Red onion, yellow onion and white onions were purchased from Bodija market, Ibadan North Local Government Area in Ibadan, Oyo state, Nigeria.

Preparation of samples

After purchase, the raw onions in fresh mass were washed, peeled and chopped using kitchen knife and chopping board. Some of the onion samples were dried before carrying out the tests while some were done in fresh mass depending on the type of analysis. The samples were dried in the oven to carry out the proximate analysis test while the other analysis was carried out in fresh mass for good results. All the tests and analysis were carried out based on the Official Association of Analytical Chemists (16).

Proximate Analysis

Samples were analysed chemically for dry matter and moisture content, ash, crude fat, nitrogen/protein, crude fibre, carbohydrate, protein, ascorbic acid, quercetin, reducing and total sugars. Analysis was done according to the official method of analysis described by the Association of Official Analytical Chemist (16). All analysis was carried out in triplicate.

Dry Matter and Moisture Determination

Moisture content determination was carried out using the air oven method. Petri Dishes were washed and dried in an oven. They were allowed to cool in the desiccator and weight was noted. A known weight of samples (5g) were then transferred into the crucibles and dried at a temperature between 103-105ºC. The dry samples were cooled in a desiccator and the weight noted. They were later returned to the oven and the process continued until constant weights were obtained.

$$\% \text{ Moisture content} = \frac{\text{Weight loss X 100}}{\text{Weight of sample}}$$

Determination of Ash Content

A known weight of finely ground sample (2g) was weighed into clean, dried previously weighed crucible with lid (W1). The sample was ignited over a low flame to char the organic matter with lid removed. The crucible was then placed in muffle furnace at 600ºC for 6hours until it ashed completely. It was then transferred directly to desiccators, cooled and weighed immediately (W2).

$$\text{Percentage Ash} = \frac{W2-W1\ X\ 100}{Weight\ of\ Sample}$$

Determination of Crude Fat

The Soxhlets extraction method by AOAC (16) was used. This method could only give the approximate fat content in a sample because all the substances soluble in chosen solvent (Petroleum ether, 40ºC 60ºC boiling range) were extracted from the sample. A known weight of sample was weighed into a weighed filter paper and folded neatly. This was put inside pre-weighed thimble (W1). The thimble with the sample (W2) was inserted into the Soxhlets apparatus and extraction under reflux was carried out with petroleum ether (40ºC – 60ºC boiling range) for 6hours. At the end of extraction, the thimble was dried in the oven for about 30 minutes at 100ºC to evaporate off the solvent and thimble was cooled in a desiccator and later weighed (W3). The fat extracted from a given quantity of sample was then calculated thus:

$$\% \text{ Fat (w/w)} = \frac{\text{Loss in Weight of sample X 100}}{\text{Original Weight of Sample}}$$

$$= \frac{W2 - W3}{W2 - W1} \text{ X } 100$$

Nitrogen/Protein Determination

The crude protein content was determined using micro Kjeldahl method as described in AOAC (17). About 0.2077g of sample was weighed into a long necked Kjeldahl flask. One tablet of Kjeldahl catalyst was added to the sample in the flask with 25cm^3 of conc. H_2SO_4. The flask was swirled, gently clamped in an inclined position and heated electricity in a fume cupboard. The heating continued until a clear solution was obtained. The clear solution was cooled, poured into a 100cm^3 volumetric flask and made up to mark with distilled water, then 10ml of the resulting mixture was measured into the distillation set through the funnel. Boric acid (5cm^3) was pipetted into a 100 cm^3 conical flask and placed at the receiving end of the distillatory. The conical flask was placed in such a way that the delivery tube dipped completely into the boric acid inside the flask. About 40% NaOH was used to liberate ammonia out of the digest under alkaline condition. During the distillation, 2 drops of methyl orange were always added to the round bottom flask containing the digested sample before 40% NaOH was added. As soon as the contents became alkaline, the red colour changed to yellow showing NaOH to be in excess. Steam was then generated into the distillation set using a steam chest. The liberated ammonia was trapped in the boric acid solution and about 50 cm^3 of the solution

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was collected into a conical flask. The solution in the flask was titrated against 0.1M HC1 until the first permanent colour change was observed.

$$\% N = \frac{\text{Molarity of HC1 X Sample titre – Blank titre) X 0.014 X DF X 100}}{\text{Weight of sample used.}}$$

% N was converted to percentage crude protein by multiplying N by 6.25.

Crude Fibre Determination

Two hundred milliliters (200ml) freshly prepared 1.25% H_2SO4 were added to the residue obtained from fat extraction and this was brought to quick boil. Boiling was continued for 30 minutes. The mixture was filtered and residue washed until it was free from acid. The residue was transferred quantitatively into a digestion flask, 1.25% NaOH was added and brought to boiling point quickly. Boiling was continued for 30 minutes. The mixture was filtered and residue washed free of alkali. The residue was then washed with methylated spirit, thrice with petroleum ether using small quantities. It was allowed to properly drain and the residue was transferred to a silica dish (previously ignited at 600^o C and cooled). The dish and its content were dried to constant weight at 105^o C. The organic matter of the residue was burnt by igniting for 30 minutes in a muffle furnace at 600^o C. The residue was cooled and weighed. The loss on ignition was reported as crude Fibre (17).

Determination of Carbohydrate

The carbohydrate content was calculated by difference thus;

% CHO = 100-(Sum of the percentages of moisture, ash, fat, protein and crude fibre)

Determination of Ascorbic Acid

The sample (100g) was weighed and grinded with a little glacial acetic acid in a mortar. The extracts were transferred into a 50 ml. volumetric flask. Then it was filtered rapidly. Ten milliliters (10mls) of the filtrate was taken into a conical flask with one drop dilute acetic acid. It was titrated against the redox dye, 2:6 dichlorophenol indophenol solution in the burette, the volume of dye required to decolorize the 10 ml of the sample. The titration was repeated using a standard ascorbic solution (1 mg pure vitamin per 100 ml.) in place of the sample extract. Hence, the amount of ascorbic acid was calculated per 100 g. of sample.

Determination of Reducing and Total Sugar

Sugar content was quantified using both the Lane and Eynon method and spectrophotometric method (colorimetric method) for all the samples AOAC (18). Reducing sugar solution was used to titrate a fixed volume of standard copper Sulphate in alkaline tartrate (Fehling) solution to methylene blue end point. All the calculations were done according to the reference table (invert sugar table for 10 mL of Fehling's solution). To avoid the effect of errors happening during the whole procedure, standard sucrose solution (1.9 mg/mL) was used and a correction factor was developed by comparing both calculated value and the table value. The whole titration procedure was done under the boiling condition and titration was completed within 3 minutes because it takes more than 3 minutes for the back reaction to take place. End point of the titration was determined very carefully. For high precision, titration was done in triplicate.

Determination of Quercetin

The ethanol extract of sample bulb was taken by hot soxhlet extraction technique for experiment. All the chemicals and reagents were of analytical grade. Solvent [n-butanol, water, acetic acid shows good spectral characteristics. Preparation of standard stock solution. The standard stock solutions of quercetin was prepared by dissolving 100 mg of quercetin standard in developed solvent [nbutanol water, acetic acid and final volume was adjusted with same solvent in 100 ml of volumetric flask to get a solution containing 1000 µg/ml of quercetin. The absorbance of the extracts was measured at 256.30 nm. The quantity of quercetin in the samples was determined from the calibration graph [AOAC (16)].

Statistical Analysis

The data obtained was analysed using Statistical Package for Social Science (SPSS) version 20. Descriptive statistics for mean, standard deviation, frequency and percentage was used in describing the data that was obtained. Analysis of Variance (ANOVA) was used to test the level of significance at $p<0.05$.

RESULTS

Table 1 shows the proximate composition of the onion samples per 100g. The moisture content ranged from 84.6 ±0.08 to 85.7 ±0.17 with Sample B having the highest moisture followed by Sample C and Sample A respectively. The protein content for Sample A and Sample C was the same (1.3±0.12) while Sample B had a protein content of 1.2 ±0.05. The crude fibre contents of the three samples were 1.1 ±0.12 for Sample A, 1.4±0.08 for Sample B and 1.2 ±0.12 for Sample C. The ash content was 0.6 ±0.05, 0.6 ± 0.08 and 0.8 ±0.08 for Sample A, Sample B and Sample C respectively. The Carbohydrates (by difference) for Sample A was 12.2 ±0.09, for Sample B it was 11.1 ±0.22 and for Sample C it was 11.4 ±0.36. The fat content ranged from 0.1 ± 0.01 to 0.16 ± 0.01 with sample B having the least and sample A having the highest fat content.

DOI: https://dx.doi.org/10.4314/jdan.v12i1.7

Table 1: Proximate composition of the onion samples percentage per 100g

PARAMETERS	Sample A	Sample B	Sample C
Moisture Content	84.60^{b} ±0.08	85.70^{a} ± 0.17	85.40^{a} ± 0.12
Protein	1.30^{a} ± 0.12	1.20^{b} ± 0.05	1.30^{a} ± 0.12
Crude Fibre	1.10^{a} ± 0.12	1.40^{b} ± 0.08	1.20^{b} ± 0.12
Ash	0.60^{a} ± 0.05	0.60^{a} ± 0.08	0.80^{b} ± 0.08
Carbohydrate	12.20^{a} ± 0.09	11.10^{a} ± 0.22	11.40^{a} ± 0.36
Fat	0.16^{b} ± 0.01	0.10^{a} ± 0.01	0.13^{b} ± 0.01

Superscripts represented with "a" are significantly ($p<0.05$) different while those represented with "b" are not significantly different

Mean ± Standard deviation of three determinations.

Sample A: Red Onion

Sample B: Yellow onion

Sample C: White onion

Table 2 shows the reducing and total sugars in the onion samples. The reducing sugars ranged from 1.1 ±0.08 to 1.8 ±0.12, with highest in Sample A (1.8 ±0.12) and Sample B having the least (1.1 ±0.08). The total sugars per sample was Sample A (2.6 ±0.12), Sample B (1.7 ±0.12) and Sample C (2.2 ±0.12).

Table 2: Reducing and total sugars (%) in the onion samples

Parameters	Sample A	Sample B	Sample C
Reducing Sugar	1.80^{a} ± 0.12	1.10^{a} ± 0.08	1.20^{b} ± 0.12
Total Sugar	2.60^{a} ± 0.12	1.70^{a} ± 0.12	2.20^{a} ± 0.12

Superscripts represented with "a" are significantly ($p<0.05$) different while those represented with "b" are not significantly different

Mean ± Standard deviation of three determinations.

Sample A: Red Onion

Sample B: Yellow onion

Sample C: White onion

Table 3 shows the anti-oxidant properties of the onion samples. The Ascorbic Acid content (mg/100g) for Sample A was 15.8 ± 0.79, Sample B was 11.2 ±0.21 and Sample C was 12.4 ±0.53. Quercetin content (mg/100g) include: Sample A (0.32 ±0.02), Sample B (0.24 ±0.01) and Sample C (0.19±0.01).

Table 3: Anti-oxidant properties of the onion samples (mg/100g)

Parameters	Sample A	Sample B	Sample C
Ascorbic Acid	15.80^{a} ± 0.79	11.20^{a} ± 0.21	12.40^{a} ± 0.53
Quercetin	0.32^{a} ± 0.02	0.24^{a} ± 0.01	0.19^{b} ± 0.01

Superscripts represented with "a" are significantly different ($p<0.05$) while those represented with "b" are not significantly different

Mean ± Standard deviation of three determinations.

Sample A: Red Onion

Sample B: Yellow onion

Sample C: White onion

DISCUSSION

The proximate analysis shows that the onions samples analyzed contained more of moisture than nutrients. Onions are nutrient dense, meaning they are low in calories but high in vitamins and minerals (20). The fair amount of nutrients in the onions can help in meeting the daily nutritional requirements when eaten in combination with other nutrient dense foods. There was significant difference in the moisture content of the onion samples (p=0.000). The highest moisture content of 85.7 ±0.17 was in red onions, which is similar to the result of Sami *et al.* (21) where a moisture content of 88.65% was recorded. It, however, varies with the result of Yahaya *et al.* (11) and Osuji *et al.* (12) where the moisture content was 93.11 ± 0.38 and 96.10% respectively. Also, the carbohydrate content in their study was very high (64.53 ± 0.98) compared to this study which recorded a very low carbohydrate content of 12.2 ± 0.09. There was significant difference in the carbohydrate (p=0.000) and protein (p=0.015) but no significant difference in the crude fibre (p=0.079), ash (p=0.058) and fat (p=0.056) content of the onion samples. The protein content of the onion samples in this study was low (1.3±0.12 to 1.2 ±0.05) which is somewhat close to the results of Osuji *et al.* (12) where the protein composition of red onions was 2.48% but contrary to the result of Sami et al. (21) who recorded a high protein content ranging from 9.22g/100 to 13.21g/100 in their study on different onion bulbs. The ash content recorded by Yahaya *et al.* (11) was 4.26 ± 0.22 which is higher than that recorded in this study in which the ash content ranged from 0.6 ±0.05 0.8 ±0.08 but the ash content recorded by Rodrígues *et al.* (22) was lower (0.33± 0.02 to 0.39± 0.03) than that recorded

DOI: https://dx.doi.org/10.4314/jdan.v12i1.7

in this study. However, the fibre content (1.4±0.08) was close to that recorded by Sami *et al.* (21) which ranged from 1.69 g/100 g to 1.81 g/100 g but low when compared to the results of Yahaya (11) which recorded a fibre content as high as 13.56±0.95.

Total sugars are sugars which are naturally present in foods such as fruits and milk as well as any added sugars (23). There is a little amount of total sugars in the onion samples which means that they are low in calories and can be consumed in considerable amounts without adverse health effects. There was significant difference (p=0.015) in the total sugars present in the onion samples. The highest total sugar was found in the red onions (2.6 ±0.12) while the lowest was found in yellow onions (1.7 ±0.12). This trend is similar with the results of Jurgiel-malecka *et al*. (19) in which the highest content of total sugars was determined in red cultivar while the lowest was yellow cultivar. However, the result of Rodrígues *et al.* (22) showed higher contents of total sugars which ranged from 3.20±0.93 to 4.1±30.72. A reducing sugar is a type of carbohydrate or natural sugar that contains a free aldehyde or ketone group and can react with other parts of the food, like amino acids, to change the color or taste of the food (24) such as glucose, fructose, lactose and maltose. The reducing sugars in this study ranged from 1.7 ±0.12 to 2.6 ±0.12, with no significant difference (p=0.053) in the reducing sugars present in the red, white and yellow onion. However, the study of Jurgiel-Malecka *et al.* (19) showed significant differences in terms of the content of reducing sugars which ranged from 95.7 g/kg to 277.7 g/kg. A study carried out for three years by Kazimierczak *et al.* (25) to see effect of different fertilization regimes on some onion characteristics showed a higher total sugar (3.10 ± 0.14 to 10.58 ± 0.20) and reducing sugars (2.04 ± 0.04 to 3.52 ± 0.10) content, which can be due to the fertilizer applied.

There was significant difference (p=0.047) in the ascorbic acid content but no significant difference (0.073) in the quercetin content of the onion samples. The ascorbic acid (vitamin C) content determined in fresh mass ranged from 15.8 ± 0.79 in red onions to 11.2 ±0.21 in yellow onions. This is similar to the results obtained by Hallmann and Rembiałowska (26) which showed a vitamin C content ranging from 7.52 to 16.96 mg/100 g. However, this is different from the result of Jurgiel-Malecka *et al.* (19) where the vitamin C content ranged from 8.13 mg/100g to 10.87 mg/100g and the result of Bieżanowska-Kopeć *et al.* (27) showed slightly lower content of vitamin C. Vitamin C - a water-soluble vitamin, is an antioxidant and an essential co-factor needed for collagen biosynthesis, carnitine and catecholamine metabolism, and dietary iron absorption (28). Onion is the most widely consumed vegetable across the globe and is also the richest source of quercetin and its conjugates (29). This study recorded a quercetin content of 0.19±0.01 to 0.32 ±0.02. This varies with the result of Salamatullah *et al.* (30) that recorded a quercetin content ranging from 0.89 ± 0.18 to 1.09 ± 0.06 in the control (un-dried) group, whereas they recorded the highest quercetin content in red onions oven-dried at 50^0C. It also varies with the work of Jung-Ho *et al.* (31) who recorded total quercetin glycosides varying from 16.10 to 103.93 mg/g DW extensively among three varieties of onions. Interestingly, Majid *et al.* (29) found out in their research that sprouted onion powders contained more phytochemicals than raw onion powder which can be of importance in product development. Both vitamin C and quercetin are antioxidants and it has been established that antioxidants help to prevent or slow damage to cells caused by free radicals in the body (32).

CONCLUSION

The study revealed the nutrients and antioxidant properties of red, yellow and white onions sold at Bodija market in Ibadan, Oyo state, Nigeria. The results show that onion is a fair source of macro nutrients and a rich source of antioxidants such as ascorbic acid and quercetin, which are important for health and wellbeing. However, the nutrients and antioxidant properties were higher in red onions compared to the other varieties (white and yellow) of onions.

Acknowledgement
The authors acknowledge the laboratory technician for carrying out the experiment Dr.Olakunle Akinpelu

Ethics approval:
Not applicable

Informed Consent:
Not applicable

Conflict of interest
No conflict of interest

Funding
Funding by authors

Author Contribution
Ani and Alfa: designed and conducted the research, wrote the paper. Adetutu: provided the materials and analyzed the data

Data and material availability
The data for the study is available on request

REFERENCES

1. McDougall GJ, Fyffe S, Dobson P, Stewart D. Anthocyanins from red cabbage-stability to simulated gastrointestinal digestion. Phytochemistry 2007; 68(9): 1285-1294.
2. Sunggil K, Doohyun B, Dong YC, Eul-Tai L Moo-Kyoung Y. Identification of two novel inactive DFR-A alleles responsible for failure to produce anthocyanin and development of a simple PCR-based molecular marker for bulb

DOI: https://dx.doi.org/10.4314/jdan.v12i1.7

color selection in onion (Allium cepa L.). Theoretical and Applied Genetics 2009; 118: 1391–1399.
3. Zhang S, Peng D, Xu Y, Lü S, Wang J. Quantification and analysis of anthocyanin and flavonoids compositions, and antioxidant activities in onions with three different colors. Journal of Integrative Agriculture 2010; 15(9): 2175–2181.
4. Yousuf B, Gul K, Wani AA, Singh P. Health Benefits of Anthocyanins and Their Encapsulation for Potential Use in Food Systems. Critical Reviews in Food Science and Nutrition 2016; 56(13): 2223-2230.
5. Ibrahim ND. Growth and yield of Onion (Allium cepa L.) in Sokoto Nigeria. Agric. Biol. J. N. Am. 2010; 1(4): 556-564.
6. Yang J, Meyers KJ, Van der Heide J, Liu R H. Varietal differences in phenolic content and antioxidant and anti-proliferative activities of onions. Journal of Agricultural and Food Chemistry 2004; 52(22): 6787-6793.
7. Rodrigues AS, Almeids D, PF, Simal-Gandara J, Perez-Gregorio MR. Onions: a source of flavonoids 2017; http://www.intechopen.com/books/flavonoids-from-biosynthesis-to-human-health. Accessed October 4, 2021.
8. Mysiak B, Tendaj M. Content of phenolic acids in edible parts of some alliums species grown for the green bunching. Acta Sci. Pol., Hortorum Cultus 2008*; 7*(4): 57-62.
9. Galeone C, Pelucchi C, Levi F, Negri E, Franceschi S, Talamini R, Giacosa A, La Vecchia C. Onion and garlic use and human cancer. The American Journal of Clinical Nutrition 2006; 84(5): 1027–1032.
10. Edet A, Eseyin O, Aniebiet E. Anti-nutrients composition and mineral analysis of allium cepa (onion) bulbs. African Journal of Pharmacy and Pharmacology 2015; 9(13); 456-459.
11. Yahaya Y, Uauri UAU, Bagudo UB. Study of Nutrient Content Variation in Bulb And Stalk of Onions (Allium Sepa) Cultivated in Aliero, Aliero, Kebbi State, Nigeria. Nigerian Journal of Basic and Applied Science 2010; 18(1): 83-89.
12. Osuji OU, Abdulrahman FI, Khan IZ, Gambo MA, Awana AU. Proximate content and elemental evaluations of Allium cepa linn. Bulletin of Pure and Applied Sciences – Chemistry 2013; 32c(1): 1-9.
13. Nassarawa SS, Sulaimann SA. Extending the shelf life of tomato and onion in Nigeria: A review. International Journal of Food Science and Nutrition 2019; 4(5): 99-111.
14. Cheng A, Chen X, Jin Q, Wang W, Shi J, Liu Y. Comparison of phenolic content and antioxidant capacity of red and yellow onions. Czech journal of food science 2013; 31: 501-508.
15. Lenková M, Bystrická J, Tóth T, Hrstková M. Evaluation and comparison of the content of total polyphenols and antioxidant activity of selected species of the genus Allium. Journal of Central European Agriculture 2016; 17(4): 1119-1133.
16. AOAC. Official Methods of Analysis of Association of Official Analytical Chemists. 18th Edition 2010; Washington, DC
17. AOAC. Official Method of Analysis of the Association of Official Analytical Chemists. 1996; Arlington.
18. AOAC. Association of Official Analytical Chemist, Official Methods of Analysis. 18th Edition 2005; Suite 500, 481 North Frederick Avenue, Gaithersburg, Maryland 20877-2417, USA.
19. Jurgiel-malecka G, Gibczynska M, Nawrocka-pezik M. Comparison of chemical composition of selected cultivars of white, yellow and red onions. Bulgarian Journal of Agricultural Science 2015; 21(4): 736-741.
20. Ware M. Why are onions good for you? Medical News Today (Newsletter) 2018; https://www.medicalnewstoday.com/articles/276714
21. Sami R, Elhakem A, Alharbi M, Benajiba N, Almatrafi M, Helal M. Nutritional Values of Onion Bulbs with Some Essential Structural Parameters for Packaging Process. Applied Sciences 2021; 11(5): 2317.
22. Rodrígues CT, Rodrígues EMR, Romero CD. Fructans and major compounds in onion culti vars (Allium cepa). Journal of Food Composition and Analysis 2009; 22: 25-32.
23. American Heart Association (AHA) Sugar 101. 2018; https://www.heart.org/en/healthy-living/healthy-eating/eat-smart/sugar/sugar-101. Accessed October 4, 2021
24. Rizzo N. The definition of reducing sugars 2021;https://www.livestrong.com/article/386795-the-definition-of-reducing-sugars/. Accessed October 4, 2021.
25. Kazimierczak R, Średnicka-Tober D, Barański M, Hallmann E, Góralska-Walczak R, Kopczyńska K, Rembiałkowska E, Górski J, Leifert C, Rempelos L, Kaniszewski S. The Effect of Different Fertilization Regimes on Yield, Selected Nutrients, and Bioactive Compounds Profiles of Onion. Agronomy 2021*;* 11(5): 883.
26. *Hallmann* E, Rembiałowska E. Antioxidant compounds content in selected onion bulbs from organic and conventional cultivation. Journal of Research and Applications in Agricultural Engineering 2006; 51: 42-46.
27. Bieżanowska-Kopeć R, Galas K, Leszczyńska T. Effect of heat treatment on the basic chemical

DOI: https://dx.doi.org/10.4314/jdan.v12i1.7

composition of onion (Allium cepa L.). Designed Food 2011; III: 7-15.
28. Abdullah M, Jamil RT, Attia FN. Vitamin C (Ascorbic Acid). In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from 2021; https://www.ncbi.nlm.nih.gov/books/NBK499877/. Accessed October 4, 2021
29. Majid I, Hussain S, Nanda V. Moisture sorption isotherms and quality characteristics of onion powder during storage as affected by sprouting. J. Food Measur. Charact 2020; 13: 775–784
30. Salamatullah A, Uslu N, Özcan MM, Alkaltham MS, Hayat K. The effect of oven drying on bioactive compounds, antioxidant activity, and phenolic compounds of white and red-skinned onion slices. Journal of Food processing and Preservation 2020; 45(2): 1-7.
31. Kwak JH, Seo JM, Kim NH, Arasu MV, Kim S, Yoon MK, Kim SJ. Variation of quercetin glycoside derivatives in three onion (Allium cepa L.) varieties. Saudi Journal of Biological Sciences 2017; 24(6): 1387-1391.
32. Hamid AA, Aiyelaagbe OO, Usman LA, Ameen OM, Lawal A, Antioxidants: its medicinal and pharmacological applications. African journal of pure and applied chemistry 2010; 4(8): 142-151.