International Food Research Journal 22(1): 332-336 (2015)
Journal homepage: http://www.ifrj.upm.edu.my

Comparative evaluation of the mineral profile and other selected components of onion and garlic

*Akinwande, B.A. and Olatunde, S.J.

Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

Article history

Received: 2 February 2014
Received in revised form: 10 July 2014
Accepted: 14 July 2014

Keywords

Onion cultivars
Garlic
Mineral contents
Pyruvic acid
Total soluble solids

Abstract

Mineral profile and some selected components of three cultivars of onion (*Allium cepa* L.) (Dan Zaria, red creole and white creole) bulb were compared with garlic (*Allium sativum* L.) clove. This was pertinent to establish their potentials in ensuring adequate nutrition and food security. Simultaneous multi-element analysis was done by inductively coupled plasma-optical emission spectroscopy (ICP-AES). Selected components determined were pyruvic acid, total soluble solids (TSS), ash content, moisture content, vitamin C and pH. The most abundant quantity minerals in the *Allium* species are potassium (14291.17-17297.88 mg/Kg), phosphorus (2491.04-4777.88 mg/Kg) and calcium (694.41-1824.29 mg/Kg). Garlic had highest amount of phosphorus and zinc (4777.88 and 66.08 mg/Kg, respectively) with least contents of calcium, magnesium, iron and aluminium. Garlic had significantly ($p<0.05$) higher contents of pyruvic acid, ash and TSS contents than onion cultivars, with increase of 88%, 130% and 104% more than the highest obtained in onion cultivars. Except for moisture and vitamin C contents, highest value (with significant difference) of all the selected components was obtained in garlic. Onion cultivar (red creole) with least content of pyruvic acid and highest content of TSS would be preferred for culinary purpose. The comprehensive mineral profile of garlic and onion samples obtained in this work is an information that could sensitize people on their need for more consumption. This can be a good opportunity to enhance micronutrient supply of the diet of low income earners which form majority of the society.

Introduction

Onion (*Allium cepa* L.) bulb and garlic (*Allium sativum* L.) clove have been cultivated since antiquity as vegetable and flavoring agents due to their characteristic pungent flavour. Their widespread use as a flavoring agent in food and for the treatment of many diseases is well known. Onions find widespread usage in both fresh and dried forms. It is used as a flavour additive in a wide variety of food formulations such as comminuted meats, sauces, soups, salad dressings and pickle relishes (Kumar *et al*., 2006).

From time immemorial, onion and garlic have been used by diverse cultural groups for treatment of parasitic, fungal, bacterial and viral infections, with investigations suggesting sulphur compounds as the main active antimicrobial agents (Rose *et al*., 2005). Other components that can also contribute to this activity are some proteins, saponins and phenolic compounds (Griffiths *et al*., 2002). Garlic is among the most used vegetables for treating Type II diabetes mellitus in diabetic women group from United States (Johnson *et al*., 2006). The combination of essential oils of onion (75%) and garlic (25%) could substitute synthetic preservatives in food safety to control fungal contamination and mycotoxin production (Kocić-Tanackov, 2012). Garlic and onion have a promoting influence on the bio accessibility of iron and zinc from food grains (Gautam *et al*., 2010).

Scientific research studies support the fact that onions and garlic are worthy of being eaten every single day in order to provide optimum health benefits. Although pungent and giving off a sulphurous odour, these foods should not be brushed aside. Consumers' tendency is currently towards foods with beneficial attributes for health and good organoleptic characteristics. The benefits of onion and garlic are well known yet many people do not eat them as much as possible. Information on multi-elements (mineral content) of onion is scanty. The present study was conducted to compare the mineral profile and selected properties of different cultivars of onion with garlic. This is important to guide in the choice to be used more often for culinary purposes.

*Corresponding author.
Email: *baishng@yahoo.com, baakinwande@lautech.edu.ng*
Tel: (+234) 803 3082 807

Materials and Methods

Plant material

Three cultivars of fresh onion bulbs, which were white creole, red creole and Dan Zaria (with white, red and brown skin, respectively), and garlic clove were used for this study. They were obtained from National Horticultural Research Institute, Idi-ishin, Jericho, Ibadan, Nigeria. The experimental design was randomized complete block design with three replicates.

Sample preparation

Representative samples of the fresh onions and garlic in three replicates were freed of their outer dry skin and sorted to remove dirt and extraneous materials. They were then cleaned with distilled water until no foreign material remained and allowed to air-dry under ambient condition for 3 h. All cleaned samples were divided into three portions. One part was cut into slices of about 2 mm thickness and dried in a cabinet drier (Hotbox Oven with fan, size 2, GallenKamp, England) at initial temperature of 50^{o}C for 6 h and then increased to 55^{o}C for 18 h. The dried slices were milled into flour with a micro mill to pass through a mesh of 150 mm screen size. The flour samples were packed in zip-lock bags and kept in covered plastic containers until used for analyses. The second part of the cleaned samples was cut into small sizes before being homogenized in Ace homogeniser for two minutes at the minimum speed setting available on the blender. The blending was intermittently done to prevent the samples from heating up. The juice of fresh tissue was strained through cheesecloth to remove pulp.

Total soluble solids, total titratable acidity, pH and vitamin C were determined for fresh homogenized samples while ash content and multi-element (i.e. mineral profile determination) were carried out on the dry-milled samples. The third portion, i.e. the fresh sample, was used for the determination of pyruvic acid and moisture contents.

Determination of multi-elements

Determination of the multi-elements was done according to the method of Zarcinas *et al.* (1987). Aliquots of three replicates (about 0.5 g) from each of the samples were weighed into cleaned digestion tube (Pyrex 50 mL-culture tubes). Into each tube was added 2 mL concentrated redistilled Nitric acid (HNO_3), covered with cling film and then left overnight at room temperature for cold digestion. The tubes were subsequently placed to a digestion block at 120^{o}C. Heating was continued and as the liquid dried off, additional 2 mL HNO_3 was added and was eventually heated to dryness. This step was repeated until the sample no longer gave off reddish – brown (ferrous oxide) fumes and the solution was clear. Addition of 1 mL solution of Nitric acid and Perchloric acid (50/50) was done into the solution in the tubes and the temperature of the block was raised to 180^{o}C and digested for 2 h. There was further increase in temperature to 220^{o}C and the solution was heated to dryness. The tubes were then removed from digestion block and allowed to cool to room temperature. The ash obtained was re-dissolved in 1 mL conc. HCl and 10 mL of 5% Nitric acid, mixed and transferred into plastic nunc tubes for analysis. The sample ash solution was injected into Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES) (model Questron Technologies Corp. TL 6000) to determine the mineral content.

Determination of total pyruvic acid content

Extraction of pyruvic acid: Pyruvic acid content was determined using dinitro pheny hydrazine (DNPH) reagent according to the method of Anthon and Barrett (2003). The samples were cut longitudinally into two pieces. One half was chopped and homogenized in Ace homogeniser with water (1:1). The filtered homogenate with cheesecloth was centrifuged at 62.61 g for 5 min and the clear extract was used for pyruvate assay to measure total pyruvic acid (Pt). The remaining half was microwaved (microwave power of 1200 W) for 1 second/g of the bulb weight to deactivate the allinase. It was cooled, homogenized in water, filtered and centrifuged as mentioned above and was used to evaluate the native pyruvic acid.

Pyruvic acid analysis: Spectrophotometric assay was carried out using 25 µL of clarified filtrate with 1 mL of distilled water and 1 mL of 0.25 g/L DNPH (prepared in 1M HCN) added to it. The reaction mixture was placed in a water bath at 37^{o}C for 10 min to allow the reaction to proceed. After removing the samples from the water bath, 1 mL of 1.5 N NaOH was added. The absorbance was recorded at 515 nm. The standard curve was constructed using 0, 2, 4, 6 and 8 mM sodium pyruvate (Sigma, Italy). The difference between the pyruvic acid content of the homogenates from unheated (Pt) and heated samples (PC) is defined as µ moles of enzymatically produced pyruvic acid (Pe) per gram garlic.

Other analyses

Moisture, ash, pH, total soluble solids and vitamin C were analyzed according to the procedures of AOAC (2000). Moisture content was determined

Table 1. Mineral contents (mg/Kg) of the *Allium* species

Mineral	Dan Zaria	Red creole	White creole	Garlic
K	*17297.88a	16022.90b	14291.17c	16675.75ab
Ca	*1824.29a	1315.85b	1368.82b	694.41c
P	2491.04d	3689.49b	3091.80c	*4777.88a
Mg	*990.59a	979.95a	862.00b	710.12c
Na	322.73c	374.28b	*407.08a	341.04c
Fe	*160.69a	118.15b	93.12c	30.16d
Al	*41.46a	28.15c	30.63b	23.30d
Zn	38.44b	31.24c	26.87d	*66.08a
Cu	27.23b	25.81c	24.73d	*28.83a
Mn	*17.39a	14.05b	11.53c	12.26c
Ni	4.38a	*5.11a	4.58a	4.48a
As	3.64b	2.87b	2.98b	*5.17a
B	2.91c	6.38b	*7.26a	5.82b
Mo	*0.42a	0.15c	0.11c	0.26b
Se	0.28c	1.03a	0.73b	*1.08a
Co	0.20ab	0.18b	*0.21a	0.19ab
Cd	1.18ab	1.11b	0.93c	*1.21a
Pb	0.26c	0.40b	0.24c	*0.54a

Means followed by different letters down the column are significantly different ($p<0.05$) from one another

*Highest value of each mineral content

by drying the samples of fresh material at 105°C till constant weight was obtained (950.46B). Ash content was determined by incinerating about 2 g sample in a muffle furnace (ELF 11/6B, Carbolite Ltd) at 600°C for 6 h until the ash turned to white color (920.153). Little drops of the juice were used to measure pH with pH meter (model 3505, Jenway). A drop of the juice was placed on the prism of refractometer (BS Eclipse 45-05) to obtain total soluble solids. Vitamin C level was estimated by iodine titration method.

Statistical analysis

Statistical analysis of all data of the three replicates was done with Statistical Analysis System (SAS) (version 9.2). Statistical significant difference ($p<0.05$) in all data was determined by analysis of variance (ANOVA) procedure. Means were separated with least significant difference using Fisher's procedure.

Results and Discussion

Mineral profile

The mineral profile of the three onion cultivars and garlic is presented in Table 1. Quantity minerals, which are potassium, calcium, phosphorus, magnesium, and sodium, have values that ranged between 14291.17-17297.88 mg/Kg, 694.41-1824.29 mg/Kg, 2491.04-4777.88 mg/Kg, 710.12-990.59 mg/Kg, and 322.73-407.08 mg/Kg, respectively. Highest contents of potassium, calcium, and magnesium were obtained in Dan Zaria (brown skinned onion), which is not significantly different ($p<0.05$) from the amount in garlic (16675.75 mg/Kg). Garlic clove had highest content of phosphorus. Phosphorus content in garlic is higher by 91.8% when compared to that in Dan Zaria and by 29.5% in red creole that has highest value among the onion cultivars. Potassium, magnesium and calcium are important in prevention and treatment of hypertension and their high intake may reduce coronary heart disease and stroke (Houston and Harper, 2008). Increases phosphorous intake also has potential to lower blood pressure (Elliot *et al*., 2008).

For the trace elements, iron, aluminium, zinc, copper, manganese and nickel have range of values of 30.16-160.69 mg/Kg, 23.30-41.46 mg/Kg, 26.87-66.08 mg/Kg, 24.73-28.83 mg/Kg, 11.53-17.39 mg/Kg, and 4.38-5.11 mg/Kg, respectively. Iron content was highest in Dan Zaria (brown skinned) when compared with the other samples. Also, range of 2.87-5.17 mg/Kg, 2.91-7.26 mg/Kg, 0.11-0.42 mg/Kg, 0.28-1.08 mg/Kg, and 0.18-0.21 mg/Kg were obtained for arsenic, boron, molybdenum, selenium, and cobalt, respectively. Garlic had highest content of zinc but with least contents of calcium, magnesium, iron and aluminium compared to the onion cultivars. According to Andreini *et al.* (2008), some transition metals including iron, zinc, manganese, and copper are very essential for life through their function as both structural and catalytic cofactors for proteins. Zinc supplementation for children between three months and five years reduces frequency and severity of diarrhea and respiratory illnesses (Aggarwal *et al.*, 2007). Selenium functions as a dietary antioxidant and thus has been studied for its possible role in

Table 2. Content of the selected component of the *Allium* Species

Allium Specie/variety	Pyruvic acid (µmol/g FW)	Ash content (%)	TSS (°Brix)	Vitamin C (mg/100 g)	pH	Moisture content (%)
Dan Zaria	23.33c	0.77c	9.73b	20.67a	5.89b	88.67a
Red creole	15.00d	1.03b	9.50b	18.00b	5.90b	86.60c
White creole	28.33b	0.90bc	8.83c	14.67c	5.85c	87.33b
Garlic	53.33a	2.37a	19.87a	8.00d	6.61a	76.93d

Means followed by different letters down the column are significantly different (p<0.05) from one another

chronic diseases (Boosalis, 2008). Only two toxic metals, i.e. cadmium and lead, were found to be present in the samples with values within the range of 0.93-1.21 mg/Kg and 0.24-0.54 mg/Kg, respectively.

Bello *et al*. (2013) reported higher values for some minerals, i.e. 2.98%, 1.22%, 0.05%, 0.04% and 0.13% for potassium, calcium, manganese, iron and copper respectively in onion bulb. In contrary, Cota *et al.* (2013) reported lower mean values for some minerals i.e. 1.313 mg/Kg, 0.72 mg/Kg, 0.324 mg/Kg, 0.221 mg/Kg, 0.015 mg/Kg and 0.003 mg/Kg for Zn, Fe, Mn, Cu, Cd and Pb, respectively, in bulbs of the new varieties of onion from Bosnia and Herzegovina. Red skinned onion (Dan Zaria) and garlic had highest content in 44% and 33%, respectively, of all the minerals discovered to be present in the analysed samples. White creole had least contents of the toxic metals. In all, garlic had the highest contents of phosphorous, zinc, copper, arsenic, selenium and lead.

Other selected components

The contents of other selected components of the allium species are shown in Table 2. Pyruvic acid level differed significantly among all the Allium samples with highest value of 53.33 µmol/g in garlic and least value of 15.00 µmol/g in red creole. This confirms the strong pungency of garlic compared to onion cultivars. White creole had higher values than Dan Zaria and red creole. This is in contrary to the report of Gallina *et al*. (2012) with white onion having lower value of pyruvic acid than red and yellow onions obtained from breeders' accession in Italy. Abedi *et al*. (2013) also reported variation in pyruvic acid content in some garlic cultivars. Pungency level in Allium species is an indirect measure of thiosulfinates content like allicin (Sance *et al.*, 2006). Consumer demand is oriented toward onion cultivars with lower pungency. Pyruvic acid content of onions is highly correlated with their pungency (Gallina *et al*., 2012). Lower content of pyruvic acid (3.35 to 8.13 µmol/g) reported for ten cultivars from Poland (Leja *et al*., 2008) could be as a result of their lower dry matter content (7.79 – 12.45%) compared to those used for this research.

Highest content for ash (2.37%) was obtained garlic and was followed by 1.03% obtained in red creole, with least content of 0.77% in Dan Zaria, which is not significantly different (p>0.05) from the value obtained in white creole. This means that the total mineral contents of garlic is higher than that in onion cultivars. Highest content of TTS (19.87 °Brix) was also obtained in garlic. Range of 8.83 – 9.73 °Brix was obtained in onion cultivars. Although there were highest contents of pyruvic acid and TSS in garlic, there is no relationship between pyruvic acid and TSS in onion cultivars.

Higher values of vitamin C (range of 14.67 – 20.67 mg/100 g) were obtained in onion cultivars while garlic had least value of 8.00 mg/100 g. Highest value of 6.61 for pH was recorded for garlic while range of 5.85 – 5.90 (in white creole and red creole, respectively) was obtained in onion cultivars. Least amount of moisture content (76.93%) was obtained in garlic while range of 86.60-88.67% was obtained in the three onion cultivars. Lower moisture content of garlic is an indication that it could be kept for longer period of time than onion.

Conclusions

As it has been shown that the *Allium* spp have potassium in abundance with very low content of sodium. This research finding could be useful to develop a food-based strategy to increase the bioavailability of trace minerals and therefore contributes to the benefit of human health. Smaller quantity of garlic could conveniently be used to flavour foods to obtain the similar nutritional benefit of some components that is obtained when higher quantity of onion cultivars is used. This is important since the current consumers' tendency is towards foods with beneficial attributes for health and good organoleptic characteristics. Regular inclusion of *Allium* spp in meals, especially in powdery form can also be a good opportunity to enhance micronutrient supply of the diet of low income earners which form majority of the society.

Acknowledgment

The authors appreciate the effort of Omodele Falohun for collection of data.

References

Abedi, M., Biat, F. and Nosrati, A. E. 2013. Evaluation of agronomical traits and pyruvic acid content in Hamedan garlic (*Allium sativum* L.) ecotypes. World Applied Sciences Journal 22 (5): 628-631.

Aggarwal, R., Sentz, J. and Miller, M. A. 2007. Role of zinc administration in prevention of childhood diarrhoea and respiratory illnesses: A meta-analysis. Pediatrics 119 (6): 1120-1130.

Andreini, C., Bertini, I., Cavallaro, G., Holliday, G. L. and Thomton, J. M. 2008. Metal ions in biological catalysis: from enzyme databases to general principles. Journal of Biological Inorganic Chemistry 13: 1205-1218.

Anthon, G. E. and Barrett, D. M. 2003. Modified method for the determination of pyruvic acid with dinitrophenylhydrazine in the assessment of onion pungency. Journal of Agricultural and Food Chemistry 83: 1210–1213.

A.O.A.C. 2000. Official Methods of Analysis (17th edition). Association of Official Analytical Chemists. Washington D.C.

Bello, M. O., Olabanji, I. O., Abdul-Hammed, M. and Okunade, T. D. 2013. Characterization of domestic onion wastes and bulb (*Allium cepa* L.): fatty acids and metal contents. International Food Research Journal 20 (5): 2153-2158.

Boosalis, M. G. 2008. The role of selenium in chronic disease. Nutrition in Clinical Practice 23 (2): 152-160.

Cota, J., Gvozdanovic-Varga, J., Hadžic, A., Petrovic, A., Saraic, E., Savic, A. and Cota, J. 2013. Yield and mineral composition of two new onion varieties from Bosnia and Herzegovina. In Kovacevic, D., (Ed). Proceedings of the Fourth International Scientific Symposium, Agrosym, pp. 251-256. Bosnia and Herzegovina: Jahorina.

Elliot, P., Kesteloot, H., Appel, L. J., Dyer, A. R., Ueshima, H., Chan, Q., Brown, I. J., Zhao, L. and Stamler, J. 2008. Dietary phosphorous and blood pressure International study of macro- and micro-nutrients and blood pressure. Hypertension 51: 669-675.

Griffiths, G., Trueman, L., Crowther, T., Thomas, B. and Smith, B. 2002. Onions – A global benefit to health. Phytotherapy Research 16 (7): 603–615.

Gallina, P. M., Cabassi, G., Maggioni, A., Natalini, A. and Ferrante, A. 2012. Changes in the pyruvic acid content correlates with phenotype traits in onion clones. Australian Journal of Crop Science 6 (1):36-40.

Gautam, S., Platel, K. and Srinivasan, K. 2010. Higher bioaccessibility of iron and zinc from food grains in the presence of garlic and onion. Journal of Agricultural and Food Chemistry 58 (14): 8426–8429.

Houston, M. C. and Harper, K. J. 2008. Potassium, magnesium and calcium: Their role in both the cause and treatment of hypertension. The Journal of Clinical Hypertension 10 (7): 3-11.

Johnson, L., Strich, H., Taylor, A., Timmermann, B., Malone, D., Tenfel-Shone, N., Drummond, R., Woosley, R., Pereira, E. and Martinez, A. 2006. Use of herbal remedies by diabetic Hispanic women in the Southwestern United States. Phytotherapy Research, 20: 250–255.

Kocić-Tanackov, S., Dimić, G., Lević, J., Tanackov, I., Tepić, A., Vujičić, B. and Gvozdanović-Varga, J. 2012. Effects of onion (*Allium cepa* L.) and garlic (*Allium sativum* L.) essential oils on the *Aspegillus versicolor* growth and sterigmatocystin production. Journal of Food Science 77 (5): M278–M284.

Kumar, D. G. P., Hebbar, H. U. and Ramesh, M. N. 2006. Suitability of thin layer models for infrared-hot air-drying of onion slices. Lebensmittel Wissenschaft Technology 39:700-705.

Leja, M., Kołton, A., Kamińska, I., Wyżgolik, G. and Matuszak, W. 2008. Some nutritional constituents in bulbs of selected *Allium* cultivars. Folia Horticulturae Ann 20 (2): 39-46.

Rose, P., Whiteman, M., Moore, P. K. and Zhu, Y. Z. 2005. Bioactive S-alk(en)yl cysteine sulfoxide metabolites in the genus *Allium*: the chemistry of potential therapeutic agents. Natural Product Reports 22: 351–368.

Sance, M. M., Bauzá, M., Camargo, A. B., González, R. E. and Soto, V. E. 2006. Evaluation of the Argentinean garlic germplasm in relation to its aptitude for the freeze drying process. Molecular Medicinal Chemistry 10: 33-34.

Zarcinas, B. A., Cartwright, B. and Spouncer, L. R. 1987. Nitric Acid Digestion and Multi-Element Analysis of Plant Material by Inductively Coupled Plasma Spectrometry. Communications in Soil Science and Plant Analysis 18: 131-146.