Turkish Journal of Agricultural Engineering Research

Turk J Agr Eng Res
(TURKAGER)

https://dergipark.org.tr/en/pub/turkager
https://doi.org/10.46592/turkager.1133558

ISSN: 2717-8420
2022, 3(2), 245-264

Research Article

Quality Evaluation of Foam Dried Watermelon Flakes

John ISA[a*], Ayoola Patrick OLALUSI[b] and Olufunmilayo Sade OMOBA[c]

[a,b] *Department of Agricultural and Environmental Engineering, The Federal University of Technology, Akure, NIGERIA*
[c] *Department of Food Science and Technology, Federal University of Technology, Akure, NIGERIA*

(*): Corresponding author, jisa@futa.edu.ng

ABSTRACT

Watermelon is mostly eaten in fresh form due to its high moisture content which is responsible for its deterioration within a short time. Foam-mat drying of watermelon was carried out using a mechanical dryer. In the foam mat drying experiments, 10% egg albumen and 2% carboxyl methylcellulose were used as the foaming agent and stabilizing agent, respectively. Thin layer drying was carried out in the mechanical dryer under temperatures of 60 and 70°C. Some nutritional qualities and chemical compositions of the watermelon were determined before and after drying. The result of the phytochemical properties revealed that the watermelon flakes have a high value of flavonoid content of 1.18±0.02 and 1.09±0.00 mg 100 g^{-1} with low terpenoid contents of 0.10±0.00 and 0.11±0.00 mg 100 g^{-1} for the sample dried using 60 and 70°C respectively. High ferric ion reducing antioxidant power (FRAP) value of 38.73±0.90 and 41.25±0.90 mg g^{-1} with low lycopene value of 0.312±0.00 and 0.323±0.01 mg g^{-1} was observed for the antioxidant properties of watermelon dried at 60 and 70ºC. The vitamin content shows that the flakes are highly rich in vitamin C (46.26±0.03 and 47.35±0.02 mg g^{-1} for 60 and 70°C, respectively) and had a low vitamin B_1 content (0.15±0.01 and 0.13±0.00 mg g^{-1} for drying temperature of 60 and 70°C, respectively). Therefore, the results of the foam-dried watermelon flakes showed that the qualities of the watermelon were preserved during drying and safe for consumption.

RESEARCH ARTICLE

Received: 21.06.2022
Accepted: 09.11.2022

Keywords:

- Watermelon,
- Nutritional qualities,
- Evaluation,
- Drying,
- Moisture content

To cite: Isa J, Olalusi AP and Omoba OS (2022). Quality Evaluation of Foam Dried Watermelon Flakes. *Turkish Journal of Agricultural Engineering Research (TURKAGER), 3(2), 245-264.* https://doi.org/10.46592/turkager.1133558

INTRODUCTION

Watermelon is produced all over the world during the warm season, mostly in areas with a lengthy growing season (Snowdon, 1990). Watermelon (*Citrullus lanatus*) is a member of the cucurbitaceous family, according to Simmond *et al.* (1976), and is thought to have originated in the arid regions of Southern Africa. Watermelon is most known for its crisp, juicy, and refreshing pulp, which is eaten as a snack. Watermelon is a good source of fluids in Africa's dry regions (Tindall, 1991). Watermelon (*Citrullus lanatus*) was also described by Robinson and Decker-Walters (1997) and Jeffrey (2001) as a significant horticultural crop, primarily renowned due to its sweet and juicy nature. According to FAOSTAT (2008), out of the total area devoted to vegetation production in African in 2008, watermelon covers about 54% and this is 4.6% of 199.194 million tons of world production of watermelon. Watermelon contains a large number of the carotenoids, and its red flesh was regarded as a reliable source of lycopene as reported by Figueroa *et al.* (2012), who also reported the probability of consumption of watermelon to be antihypertensive. Watermelon has some other important values such as the vitamins, high moisture, and trace of cholesterol, therefore, it is consumed for its therapeutic value, which includes thirst-quenching and anti-inflammatory compounds. Which is the major cause of asthma, atherosclerosis, diabetes, colon cancer and arthritis (Sundia, 2007) and (Isa and Olalusi, 2019).

Alam (2013) reported that watermelon is one of the under-utilized fruit majorities grown in the tropical part of the world despite its nutritional value. Watermelon has a layer of white-fleshed internal ring and interior or edible flesh with high variability in thickness based on their maturity and size and the major problem of this crop include its high perishability. Several researchers such as Johnson *et al.* (2013), Oseni and Okoye (2013), Parmar and Kar (2009), Lakshmi and Kaul (2011), Fila *et al.* (2013), Gin *et al.* (2014), Egbuonu (2015), Adedeji (2017), Isa and Olalusi (2019), Munawar *et al.* (2020) have reported some properties of the fresh watermelon but less information is available on the compositional properties for both the fresh watermelon and its flakes.

The process of eliminating or lowering moisture from an agricultural product in order to improve its characteristics and attributes is known as drying. However, Foam mat drying, on the other hand, is a method for drying in which a liquid or semi-liquid concentration of agricultural material is whipped into a foam-like substance and then dried by exposing the product to hot air in a thin layer. Foam mat drying is a type of drying in which a concentration of agricultural material in a liquid or semi-liquid condition is whipped to create a foam-like substance and then dried by exposing the product to hot air in a thin layer. Morgan *et al.* (1961) developed the first foam mat drying process, after which several researchers report the further process and application (Ginnette *et al.*, 1963; Hart *et al.*, 1963; Berry *et al.*, 1972; Berry *et al.*, 1965). The foam mat method was a good process of dehydrating temperature-sensitive food material with great advantage in the reconstitution of the dried product and energy-saving by shorting the drying time. Jagtiani *et al.* (1998) reported that the drying temperature for a foam mat drying process range between 50°C and 70°C. Javed *et al.* (2018) also, reported the increasing surface area as a factor that accelerates the drying process as it enhances the moisture removal, therefore, foam mat drying of liquid and semiliquid food and make them into foam, based on the liquid level the

addition of foaming and the stabilizing agent makes the dried product easily convertible to powder. However, this study aims at the quality evaluation of watermelon puree before and after the foam mat drying process in a mechanical dryer.

MATERIALS and METHODS

Preparation and collection of samples: watermelon sample (sugar baby varieties) was obtained from Oja Oba market in Akure south local government of Ondo State, Nigeria. Prior to the commencement of the drying experiment, the flesh was pulped and homogenized using a home mixer after the rind was separated from the flesh and the seeds were removed. An electric blender (Orpat-HHB100E, Ajanta Limited, India) was used to whip a known-weight sample size at 1800 rpm. On a wet juice weight basis, the foaming ingredient is egg albumen (10%) with food-grade methylcellulose (stabilizing agent) at 2%. During the whipping process, egg albumen and methylcellulose were added to foam and stabilize the watermelon juice (Javed *et al.*, 2018).

Foam-mat drying experiment

A mechanical drier with a heating chamber, air blower, drying air outlet holes, and temperature regulator was employed for the drying of the foamed watermelon pulp in a food-grade stainless steel tray. The drier was turned on for a while to keep the chamber at the correct temperature. The homogenous foamed watermelon pulp was dried at constant air velocity (1.0 m s^{-1}) under 60 and 70°C. The foam-mat was peeled and packed for further investigations and analysis when it had dried to the point where the weights of the samples recorded had become consistent values.

Important drying parameters

Moisture ratio: Equation 1 express the moisture ratio based on the moisture content during drying:

$$MR = \frac{M_t - M_e}{M_0 - M_e} \quad (1)$$

Because the M_e value is so little in comparison to the M_o and M_t, it was ignored, and the moisture ratio may be written as shown in Equation 2

$$MR = M_t / M_o \quad (2)$$

Where M_t is the moisture content in a time (%), M_e is the moisture content at equilibrium in (%), and M_o is the initial moisture content in (%), and MR is the dimensionless moisture ratio.

Moisture content: The amount of moisture in a substance can be stated as a decimal or a percentage, and it can be expressed wet or dry. The moisture content on a wet basis is the weight of moisture in a product per unit weight of undried material, denoted as shown in Equation 3.

$$Mwb = \frac{wo - wd}{wo} * 100 \quad (3)$$

W_0 is wet sample's starting weight, W_d is the sample's dried weight, M_{wb} is the sample's moisture content on a wet basis, and M_{db} is the sample's moisture content on a dry basis.
Drying rates: Agricultural products differ from most other materials that are frequently dried, such as laundry, sand, stone, dust, or paper. Agricultural things (which are hygroscopic) normally retain some moisture after drying, but non-hygroscopic materials can be dried entirely. Due to hygroscopic substances, moisture is trapped in constricted capillaries. The rate of moisture flow is only approximately proportional to the vapour pressure differential with the environment due to the crop's resistance to moisture flow. As a result, Equation 4 was used to compute the drying rate of the foam dried product:

$$Drying\ rate\ = \frac{M_{t+dt} - M_t}{dt} \quad (4)$$

Proximate analysis
Standard analytical techniques were used to determine the proximate components (AOAC, 1995) of the fresh and dried watermelon flakes.

Moisture content determination: The moisture content of the sample was determined using the AOAC method. In the oven, the Petri-dish was properly cleaned and dried. 100 g of the material was then placed in a pre-weighed Petri plate and dried at 105°C for two hours. The dish and dry sample were moved to the desiccator to cool to room temperature before being weighed again.

Ash content determination: The inorganic residue left after the sample's organic substance has been destroyed is represented by the ash content of the material. For 4-6 hours, keep the silica dish in the Muffle furnace at no more than 525-550°C. Calculate the percent ash by weighing the ash and using the calculation provided in the standard procedure. In a muffle furnace, about 5 g of the material was weighed into a crucible and cooked for 6 h at 500°C until it turned grey ash or white. The plate was withdrawn from the muffle furnace and placed in the desiccator to cool using crucible tong. It was re-weighed when it cooled, and the difference was used to compute the ash weight. The ash content was determined using the method described by AOAC (1995) as shown in Equation 5

$$\%\ ash\ content = \frac{weight\ of\ ash}{weight\ of\ sample} \times 100 \quad (5)$$

Fat content determination: The soxhlet fat extraction technique AOAC (1995) was used to calculate fat content. A 250 mL boiling flask was completely cleaned and dried in a 105°C oven for 30 minutes before cooling in a desiccator. Following that, the dried sample was accurately weighed into labelled thimbles, yielding a total weight of 2 g. In a cooled boiling flask, 200 mL petroleum ether was heated to 40-60°C. After the extraction thimble was gently blocked and the boiling flask containing the petroleum ether was allowed to boil in the extraction thimble, the Soxhlet apparatus was allowed to reflux for 6 h. The flask was withdrawn after it was clean of petroleum ether and heated for 1 h at 105°C. It was moved from the oven to the desiccator to cool before weighing.

$$\% \, fat \; content = \frac{weight \; of \; ether \; soluble \; material}{weight \; of \; sample} \times 100 \quad (6)$$

Fibre content determination: The crude fibre was an organic residue that remained after the food sample was treated under controlled conditions with conventional hot acid and alkali solutions. In a 250 mL conical flask, 2 g of the sample was weighed, 200 mL of 1.25 percent H_2SO_4 was added, and the mixture was heated under reflux for 30 minutes. The solution was filtered through Whatmann filter paper and washed with hot water until it was no longer acidic, as shown by the pH paper. The residue was transferred to a 250 mL beaker, and 200 mL of 1.25 percent NaOH was added.

After boiling for 30 minutes in a digestion apparatus, the mixture was filtered and washed with distilled water until the filtrate was pH paper neutral. The residue was transferred to the crucible and dried in an electric oven for 8 hours at 100°C. After that, it was removed and placed in a desiccator to cool before being weighed. The material was weighed first, then burned, desiccated, then weighed once more. The crude fibre content was calculated as follow:

$$\% \, Crude \; fibre = \frac{fibre \; weight}{weight \; of \; sample} \times 100 \quad (7)$$

Protein content determination: The Kjeldahl method was used to determine the sample's composition. To calculate the protein content, total nitrogen was multiplied by a conversion factor of 6.25. A selenium catalyst was introduced to a Kjeldal digestion flask containing 0.5 g of the sample. The flask was filled with just 20 mL of H_2SO_4, 10 g of Na_2SO_4, and 1 g of $CuSO_4$, and the solution was digested by heating in a fume cupboard until it was completely digested and became blue. The titration solution was removed and used with caution. When colour of the distillate reverted to the light pink hue of the boric acid and screen methyl red indicator combination, the titration was completed.

Carbohydrate determination: Using the arithmetic difference approach, the carbohydrate content of the test sample was calculated.

$$\% \, CHO \; = \; 100 - (\% \, fat. + \% \, ash \; + \; \% fiber + \% protein) \quad (8)$$

Analysis of phytochemicals

Alkaloid determination: On a steam water bath, 0.5 g of the extract was agitated in 5 ml of 1% aqueous HCl, 1 ml of the filtrate was treated with a few drops of Dragendorf reagent, and blue-black turbidity was obtained as early evidence for the presence of alkaloid.

Saponin determination: The content was determined using a screening technique based on the stability of saponin to created foam in an aqueous solution. 0.5 g of extract shaken with distilled water in a test tube foaming that persists after warming was employed as a preliminary confirmation for the presence of saponin. Brunner's spectrophotometric approach was used to determine saponin content (Brunner, 1984). In a 250 mL beaker, 2 g of finely powdered material was weighed, and 100 mL of isobutyl was added. To ensure even mixing, the mixture was shaken for 5 hours. Using No. 1 Whatman filter

paper, the mixture was filtered into a 100 mL beaker containing 20 mL of a saturated 40% magnesium carbonate solution ($MgCO_3$). To achieve a clear colorless solution, the combination is filtered once more using No 1 Whatman paper. Using pipette, 1 mL of the colourless solution was transferred to a 50 mL volumetric flask, which was then filled to the mark with 2 mL of 5 percent iron (iii) chloride ($FeCl_3$) solution and distilled water. It was left for 30 minutes to allow the colour to develop. The absorbance was compared to a blank at 380 nm.

Tannin content determination:
A black green precipitate was generated by combining 0.5 g of the extract with 100 ml of distilled water, filtering the filtrate, and adding ferric chloride reagent to the filtrate. In a 50 ml sample container, 0.2 g of finely powdered material was weighed. A total of 10 mL of 70% aqueous at 30°C in an ice bath shaker. The supernatant from each solution was frozen after centrifugation.

0.2 ml of each solution was pipetted into the test tube, then add 0.8 ml of pure water. 0.5 mg ml^{-1} of stock and 1 mL purified water were used to make standard tannic acid solutions. Both the standard and the sample received 0.5 mL of Folinciocateau reagent, followed by 2.5 mL of 20 percent Na_2CO_3. After vortexed and incubated for 40 minutes at room temperature, the absorbance was measured at 725 nm against a reagent blank concentration of the same solution from a standard tannic acid curve (Makkar, 1996).

Determination of flavonoid content: 1 mL aqueous extract was combined with 1 mL lead acetate solution (10%). The presence of a yellow precipitate was defined as a positive test for flavonoids (Njoku and Obi, 2009). A 0.5 g extract was treated with 20 mL of mild ammonia solution. The yellow colour was erased with the addition of mL conc. H_2SO_4, suggesting the presence of flavonoids.

Determination of steroid content: Add 10 mL chloroform to 200 mg plant extract. 2 mL of this filtrate, 2 mL acetic anhydride, and 2 mL conc. H_2SO_4 steroids are shown by the blue green ring (Siddiqui *et al.*, 2010). In each extract of 0.5 g, 2 mL of acetic anhydride and 2 ml of H_2SO_4 were added. The presence of steroids was indicated by the change in hue of several samples from violet to blue or green (Egwaikhide and Gimba, 2007).

Determination of terpenoid: 3 mL of the concentration was filtered after 0.5 g of the extract was mixed with 20 mL of chloroform H_2SO_4 was added to the filterate to create a layer. Near the touch, a reddish-brown tint was seen, suggesting the presence of terpenoid. According to Sofowora (1993), a technique was used. 0.5g of finely powdered material was weighed into a 50 mL conical flask, and 20 mL of chloroform methanol 2:1 was added. The mixture was properly mixed before being placed aside for 15 minutes at room temperature. The suspension was centrifuged at 3000 rpm, the supernatant was discarded, and the precipitate was washed twice with 20 ml chloroform: methanol 2:1 and centrifuged before being dissolved in 40 ml of 10% SDS solution. Before measuring absorbance at 510 nm, 1 ml of 0.01 M ferric chloride was added and left for 30 minutes.

Determination of antioxidant properties:

Determination of antioxidant properties: Sadler *et al.* (1990) described a modified version of their technique, which was reported by Ambreen *et al.* (2013) was used in this study.

The lycopene content was determined using a modified version of the method described by Sadler *et al.* (1990). About 0.6 g of material was mixed with 5 ml of acetone containing 0.05 percent (w/v) BHT, 5 ml of 95 percent ethanol, and 10ml of hexane. The homogenate was centrifuged for 15 minutes at 400 g at 4°C. Three milliliters of distilled water were then added. To aid phase separation, the vials were shaken for 5 minutes and then stored at room temperature. A spectrophotometer was used to measure the absorbance of the top hexane layer in a 1cm-pathlength quartz cuvette at 503 nm.

Hexane was used as the blank and the Ambreen *et al.* (2013) approach was used to assess total phenol, ferric reducing antioxidant power (FRAP), and 2.2-diphenyl-1-picrylhydrazyl (DPPH). Arunachalam *et al.* (2014) used the technique described by Arunachalam *et al.*, (2014) to assess the amount of 2,2-azinobis (3-ethyl benzothiazoline)-6-sulfonic acid (ABTS), -carotene, and lycopene. The following equation was used to calculate the sample's lycopene content:

$$ycopene\left(\frac{mg}{kgoftissue}\right)=\frac{A_{503}\times 31.2}{MassofTissue\ (g)} \quad (9)$$

Where A503 is the absorbance of the upper hexane layer.

Data analysis

The data for each treatment: Fresh and foam dried watermelon (60 and 70°C) were repeated in triplicate. The quality parameters were visualized using bar chart on MS excel version 2016. The treatments were compared using mean comparison (Tukey test) at 0.05 probability level on XLSTAT version 2018.

RESULTS AND DISCUSSION

Drying curve

Figure 1 shows the moisture profile of the foam dried watermelon as a function of drying time at two different temperatures (60 and 70°C). The figure shows that the moisture content obtained for the final products of watermelon puree reduces with 74.81 and 81.04% for the drying temperature of 60°C and 70°C, respectively. However, the foam mat drying process of watermelon (using 10% egg albumen and 2.0% CMC) was found to be affected by increase in temperature, as increase in temperature increases the specific amount of moisture removed from the sample and reduces the required drying time for complete drying process Franco *et al.* (2015) found a similar conclusion in his research of the influence of process factors on yacon foam mat drying kinetics (*Smallanthus sonchifolius*), Noordia *et al.* (2020) also arrive on the same conclusion in his research on foam mat drying of banana juice.

The moisture drying rate pattern during the drying process of the foam dried watermelon (10% egg albumen and 2.0 percentage of CMC) at two different drying temperatures show a similar trend but different magnitude. the rate of drying of the foamed watermelon increase with increase in the temperature as shown in Figure 2 where the drying rate was calculated as a function of drying time and moisture content. However, no consistent drying rate period was seen in the drying curves for this investigation at any drying setting. After an initial fast rise, the drying rate falls constantly with time and with decreasing moisture content, and the whole process occurred throughout the falling rate phase. This finding is consistent with the findings of Togrul and Pehlivan (2004), Akpinar *et al.* (2006), Shivani *et al.*, (2019).

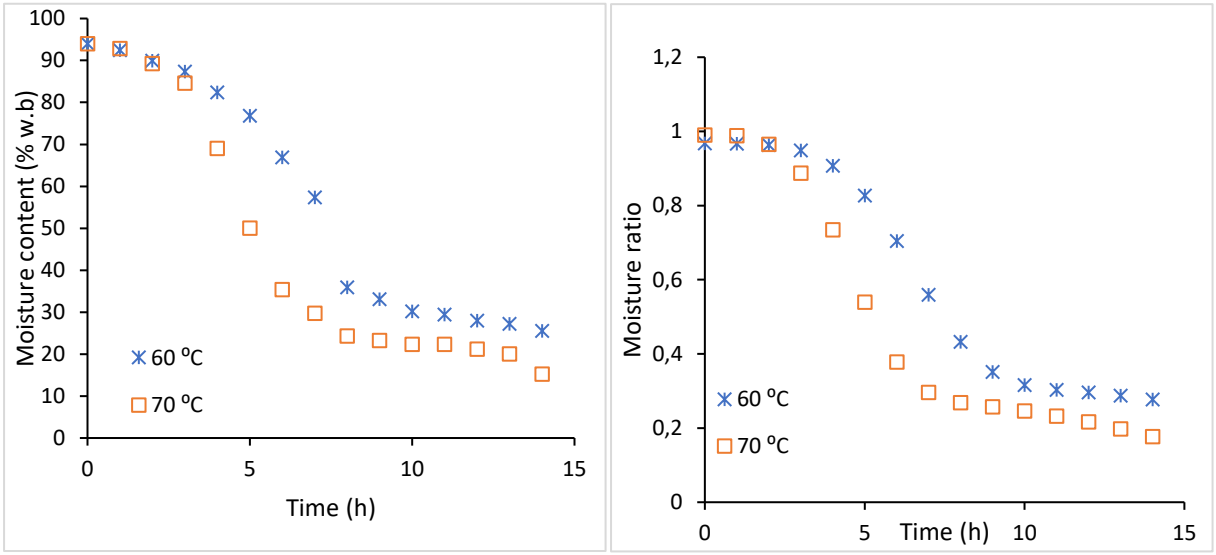

Figure 1. Moisture content and moisture ratio vs drying time.

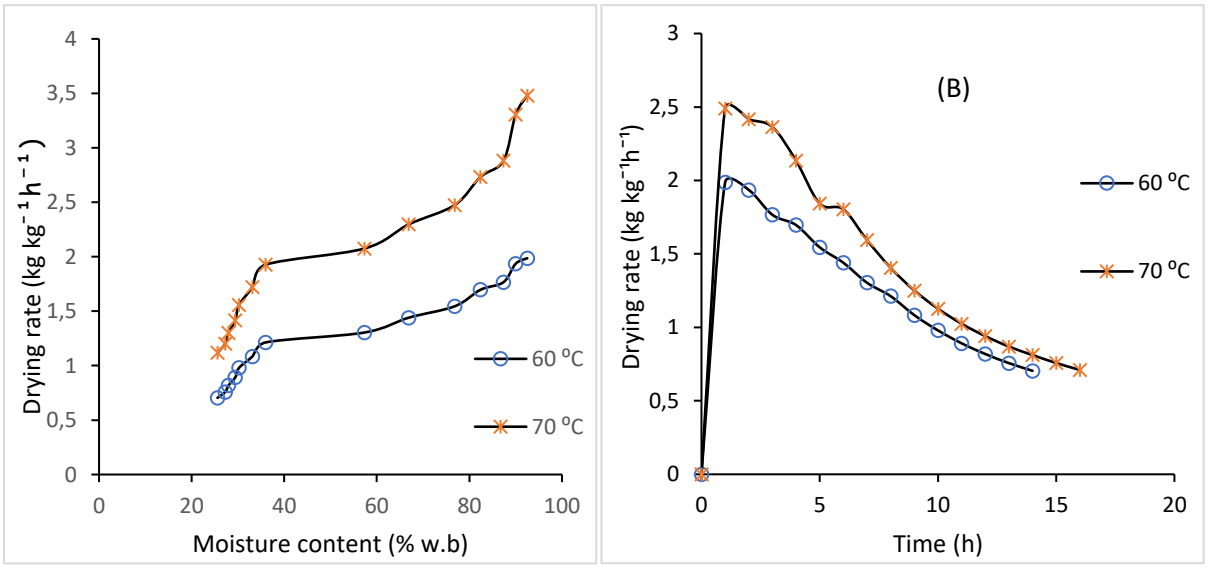

Figure 2. Drying rate *Vs* (A) moisture content and (B) drying time under different temperature.

Nutritional composition of watermelon

Proximate composition: The moisture, ash fat, fibre, protein and carbohydrate (CHO) content of fresh watermelon flesh were 90.03±0.38, 5.20±0.40, 0.19±0.01, 0.20±0.05, 1.05 and 3.32±0.40% with energy of 21.08±1.63 kcal 100 g^{-1}. The result of the proximate composition of foam dried watermelon flakes at different temperature (60°C and 70°C) in comparison with the proximate composition of the fresh sample is presented in Figure 3. The composition includes moisture (3.980.02; 4.440.014), ash (5.650.011; 11.850.0008), fat (4.060.063; 4.12 0.007), fibre (1.060.001; 1.120.000), protein (3.510.014, 3.280.035) and CHO (81.740.057%, 75.20.019%) of the foam dried watermelon at different temperature (60°C; 70°C, respectively). The results of the proximate analysis in this study were similar to those published by Ambreen *et al.* (2013) who reported the moisture, protein, fat, ash and nitrogen-free-extract (NFE) and CHO content of fresh watermelon as 92.02±1.65, 0.49±0.02, 0.11±0.001, 0.32±0.06, 0.27±0.03 and 6.79±0.25%, respectively and According to Inuwa *et al.* (2011), the moisture, ash, protein, fat, and fiber content of fresh watermelon ranged from 93.40 to 94.60%, 0.50 to 0.60%, 0.10 to 0.15 percent, 0.30 to 0.40%, and 0.50 to 0.55%, respectively. The small changes in watermelon content might be attributed to varietal differences (Yau *et al.*, 2010), harvesting period or season (Arocho *et al.*, 2012) and flesh crispness (Shofian *et al.*, 2011) of the fresh watermelon. The current results are likewise consistent with the USDA (2010) that published the values for the proximate composition of watermelon as 91.45 g moisture in 100 g sample of watermelon and the remaining characteristics like protein, fat, ash, and dietary fiber as 0.61, 0.15, 0.25, and 0.40 g 100 g^{-1}. Nevertheless, for the foam dried watermelon flake, the low moisture content implies that there will be an increase in the lifespan of the foam dried watermelon concentrates as it is significantly lower than that of the fresh sample. The ash content of the sample dried at 70°C in this study is significantly higher ($P<0.05$) than that of 60°C, which is not statistically different from the fresh sample. The value published by Inuwa *et al.* (2011), and the high ash content in the sample shows the percentages of inorganic mineral elements contained in watermelon flakes, and high mineral elements in foods improve growth, development and also accelerate metabolic processes in the human body. The fat and fiber content of the foam dried watermelon produced in this investigation is greater than the results reported by Ambreen *et al.* (2013). This study's fiber content ranged between 1.06 and 1.12%, which was greater than the results of Ambreen *et al.* (2013) and Inuwa *et al.* (2011). Fiber is thought to lower the level of cholesterol in human blood, as well as the risk of certain malignancies. The watermelon flakes had a high carbohydrate content, suggesting that they may also be used as a source of carbohydrate, while the protein level was greater when compared to the results of Ambreen *et al.* (2013) and Inuwa *et al.* (2011).

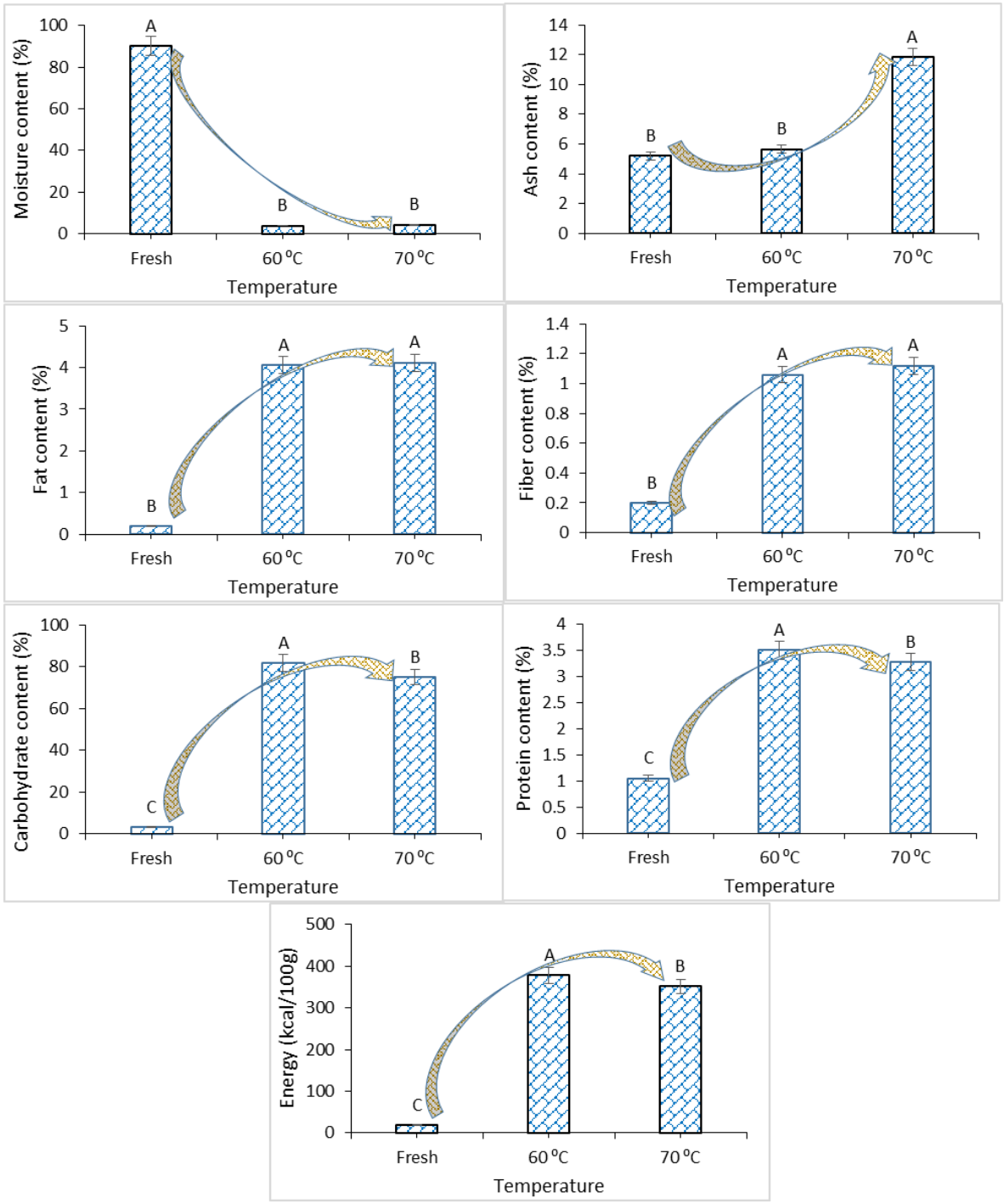

Figure 3. Proximate composition of fresh and dried watermelon: the column shows the magnitude of the content; the error bar denotes the standard deviation; the arrow shows the increment or decrement and bar with the same alphabet are not significantly different ($P<0.05$).

Mineral content of watermelon

Figure 4 depicts the mineral compositions of fresh and foam-dried watermelon. The figure shows the presence of K, Na, Fe, Mg, and Cu in the pulp is 173±5.0, 1.5±0.04, 0.4±0.01, 15.4±0.25 and 0.1±0.003 mg $100g^{-1}$ respectively in fresh watermelon. The mineral content (mg $100\ g^{-1}$) of foam dried watermelon flakes showed the presence of K (53, 46), Na (8.6, 5.2), Fe (0.15, 0.18), Mg (264, 271), Cu (142, 153,) and Na: K (0.37, 0.30) at the temperature of 60°C and 70°C, respectively.

The result for the fresh watermelon agrees with the value reported by Ambreen et al. (2013) on watermelon juice were 126±2.36, 0.81±0.03, 0.26±0.01 and 0.031±0.001 mg 100 g^{-1} were reported for K, Ca, Na, Fe, and Zn respectively and Nagaski (2006) reported, Na, K, Ca, and Fe had concentrations of 60 mg 100 g^{-1}, 2 mg 100 g^{-1}, 145 mg 100 g^{-1}, and 24 mg 100 g^{-1}, respectively, which are greater than the results of this study,

Inuwa *et al.* (2011) found that the iron level of watermelon varied from 0.18 to 0.33 mg 100 g^{-1}. Furthermore, Proietti *et al.* (2008) reported 154 mg 100 g^{-1} potassium in watermelon. According to Colla *et al.* (2006), potassium concentrations varied from 107 to 114 mg 100 g^{-1}, with Na, Ca, and Mn concentrations of 0.70, 6.40, and 0.027 mg 100 g^{-1}, respectively. The variation in agronomic techniques, geographical circumstances, ripening stage, and harvesting season ripening stage, and harvesting season might all have an impact on the mineral content of fresh watermelon in this study. The minerals contained are extremely beneficial to the body's health. Nonetheless, the magnesium and potassium content of the foam dried sample is lower than that of the fresh sample, but the magnesium content is unaffected by changes in the system's temperature.

Except for the potassium content in the foam dried watermelon, which increases significantly with increased system temperature, all other minerals selected for this study show that their composition in the foam dried watermelon is significantly higher than the fresh watermelon at ($P<0.05$) and their values significantly decrease with increased system drying air temperature, with the exception of the potassium content in the foam dried watermelon. This research, however, has a high iron content, which aids in the production of blood and the transfer of O_2 to CO_2 from one tissue to another. In children, iron deficiency causes academic difficulties and behavioral issues, as well as anemia. Furthermore, the potassium content reported by ranges from 107 to 114 mg 100 g^{-1} which was low when compared with the result of this study. People who take diuretics to manage and suffer from excessive potassium excretion through the bodily fluids benefit from high potassium because it promotes iron consumption. Potassium may be found in a variety food, including fruits, dairy products, and vegetables. And it has a daily consumption recommendation of 3500 mg. The obtained result, Na, 0.70 mg 100 g^{-1}, is close to the suggested threshold. This is a modest number when compared to the experiment's outcome. Sodium helps muscles and neurons function properly by regulating fluid equilibrium in the body. The daily sodium requirement for adults and children aged 4 and others 2400 mg. However, because the sodium-potassium ratio (Na/K, 0.30 to 0.37 mg g^{-1}) is less than 1, the foam dried watermelon is safe for hypertension patients to consume (Ambreen *et al.*, 2013; Inuwa *et al.*, 2011; Proietti *et al.*, 2008; Nagaski, 2006; Adedeji, 2017).

Vitamin content of the watermelon

Foam dried watermelon flakes of different temperatures (60°C and 70°C) were investigated for their vitamin content and the results are presented in Figure 5. It was observed that Retimol (VA), Thiamine (VB_1), Riboflavin (VB_2), Niacin (VB_3), Pyridoxine (VB_6), B_{12} and Ascorbic acid (VC) content of fresh watermelon are 693.43±18.61 mg ml^{-1}, 3.25mg g^{-1}, 0.137±0.176mg g^{-1}, 0.233±0.012 mg g^{-1}, 0.117±0.006mg g^{-1}, 0.006±0.001mg g^{-1} and 11.747±0.211 mg 100 g^{-1} respectively. The vitamin content (mg g^{-1}) includes: VA (17.34±0.184, 13.24±0.028), VB_1 (0.14±0.003;

0.13±0.001), VB_2 (0.15±0.001; 0.96±0.004), VB_3 (1.66±0.002, 1.12±0.001,), VB_6 (0.50±0.002; 0.53±0.003), VB_{12} (0.77±0.001; 0.81±0.006), and VC (46.26±0.028; 47.35±0.021) at the temperature of 60ºC and 70ºC, respectively. The result reveals the presence of vitamin C and A at a very high quantity, the vitamin content is found higher when subjected to a high drying temperature of 70°C. Vitamin B_1 and B_2 were found in a close range (0.1-1.00) for both temperatures selected for this study. B and C vitamins are known to be water-soluble and heat-labile, which might explain why they are being depleted. The vitamin A, B_6, and C levels found in fresh watermelon are identical to those found in a paper by USDA (2010). However, the result shows that Vitamin A and B_1 content of the foam dried sample is lower compared to the fresh sample but the value obtained under the two temperatures of the system has no significant ($P>0.05$) difference for Vitamin A. The Vitamin B_1 content of the foam dried watermelon decreases significantly ($P<0.05$) with increased system temperature, whereas all other selected vitamins in this study show that the vitamin content in the foam dried watermelon is significantly ($P<0.05$) higher than fresh watermelon and the value significantly increases with increased dryer drying air temperature. Except for the Vitamin B_3 content, which decreases significantly ($P<0.05$) with increased dryer drying air temperature.

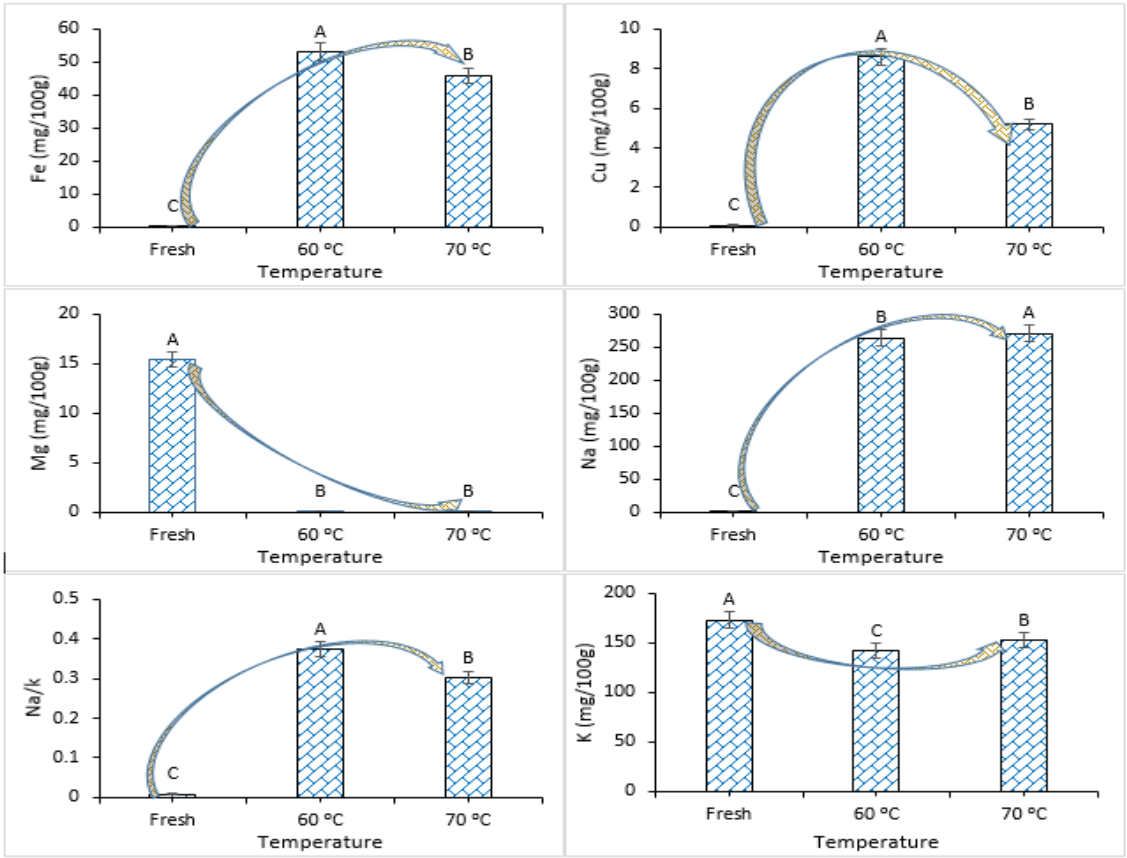

Figure 4. The mineral composition of fresh and dried watermelon the column shows the magnitude of the content; the error bar denotes the standard deviation; the arrow shows the increment or decrement and bar with the same alphabet are not significantly different ($P<0.05$).

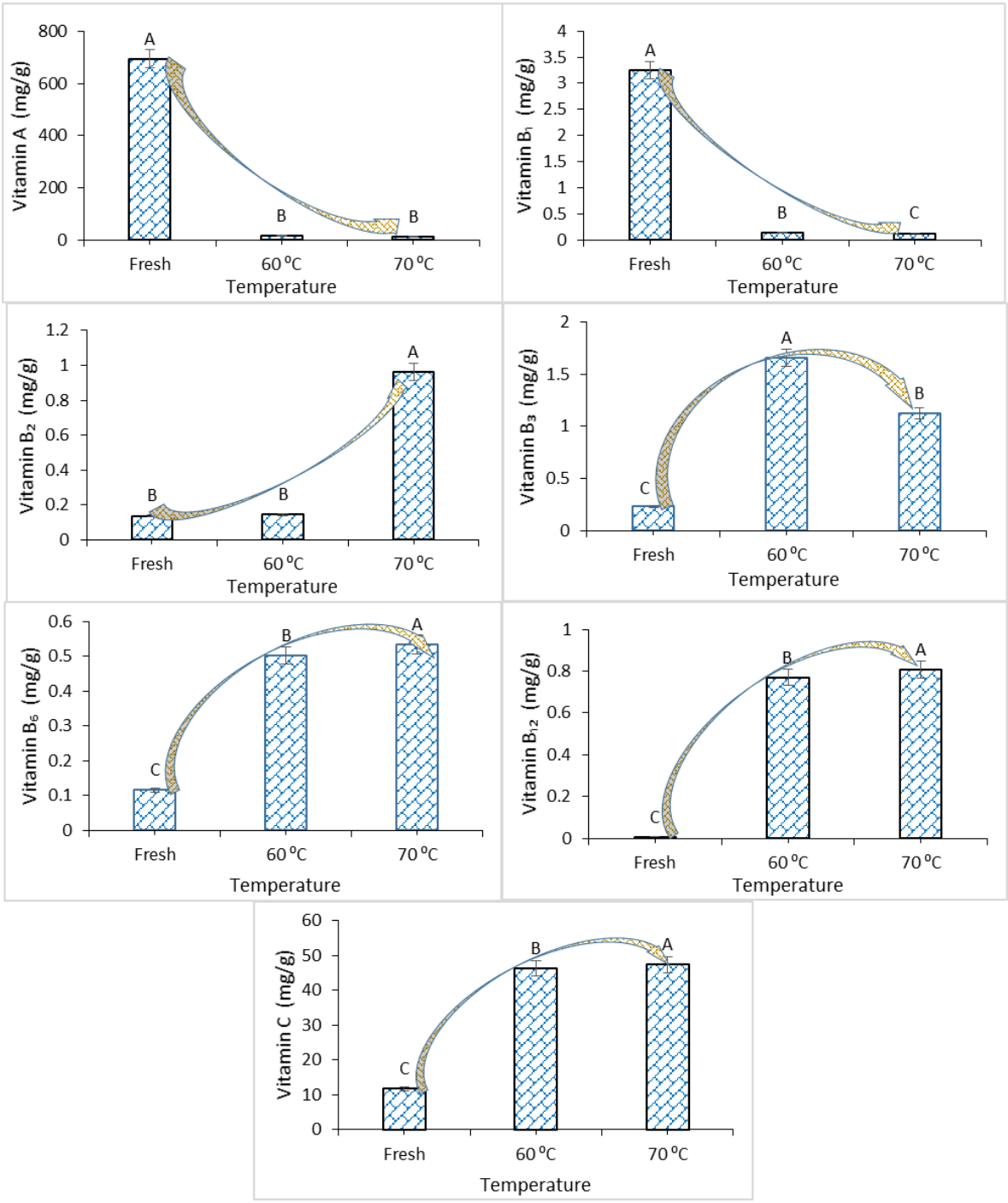

Figure 5. Vitamin composition of fresh and foam dried watermelon; the column shows the magnitude of the content; the error bar denotes the standard deviation; the arrow shows the increment or decrement and bar with the same alphabet are not significantly different ($P<0.05$).

Antinutritional composition of watermelon

Phytochemical composition: The knowledge of phytochemical composition in food offers understanding of the food's pharmacologic, nutritional, and hazardous potential flavonoid, saponins, alkaloids, and tannins (Figure 6). The flavonoid concentration in the pulp (2.40±0.1%) was lower compared to the range 36.8±120 – 39.6±0.02 mg 100 g^{-1} in *Solanum incanum* (Auta *et al.*, 2011), but in agreement with the value (2.15±0.05) reported for roasted dehulled *Trculia Afreicana* (Ijeh *et al.*, 2010). Because the flavonoid contains antifungal and antibacterial characteristics, their presence in the samples

implies that their usage might protect against diseases caused by free radicals, bacteria, and fungi (Adeolu and Enesi, 2013). Saponins have a bitter taste that may be linked to pharmacologic properties such as hemolytic activity (Sodipo *et al.*, 2000). Adeolu and Enesi (2013) and Chaux-Gutiérrez *et al.* (2017) report positive benefits on blood cholesterol levels, bone health, cancer, and immune system activation. Alkaloids (low concentration) are therapeutically useful natural plant chemicals because of their analgesic, antispasmodic, and antibacterial properties (Adeolu and Enesi, 2013). The pulp's alkaloid concentration (0.040.03%) is lower than the range seen in *Treculia Africana* seeds (0.350.05 to 0.580.08%) (Ijeh *et al.*, 2010).

The tannin concentration of the pulp (1.33±0.03%) is higher than that of sweet potatoes leaves (0.21±0.02) by Antia *et al.* (2006), but lower than that of *Treculia Africana* seeds (Ijeh *et al.*, 2010). Also, the values given by Egbuonu (2015) for watermelon are extremely comparable. The watermelon pulp flavonoid concentration (2.40±0.1%) is lesser than the flavonoid content (36.8±1.20-39.6±0.02 mg 100 g^{-1}) of raw and processed *Solanium Incanum* (Auta *et al.*, 2011).

Because the flavonoids contain antifungal and antibacterial characteristics, their presence in the samples implies that their usage might protect against diseases caused by free radicals, bacteria, and fungi (Adetola and Enesi, 2013). The identification of tannins in particular suggested the product might contains astringents and antimicrobials (Adeoju and Enesi, 2013) and could be used to trat a variety of ailments, such as inflammation, kidney failure, liver problems, hypertension and reactive oxygen species inhibition (Zhu *et al.*, 1997; Cakmak, 2020).

However, the phytochemical properties of foam dried watermelon flakes are presented in Figure 6. The alkaloid, tannin, flavonoid, steroid, saponin and terpenoid contents were 0.45±0.014, 0.34±0.021, 1.18±0.021, 0.82±0.001, 1.07±0.021, 0.10±0.004 mg g^{-1} respectively at drying air temperature of 60°C and 0.39±0.007, 0.32±0.014, 1.09±0.007, 0.88±0.001, 1.03±0.021, 0.11±0.002 mg g^{-1} respectively at temperature 70°C. Johnson *et al.* (2013) reported similar results for dried watermelon where, saponin, alkaloid, tannin, phytate, flavonoid, oxalate and phenol contents were obtained as 3.08±0.05, 0.35±0.00, 0.18±0.01, 0.10±0.01, 3.20±0.10, 0.03±0.0001, 0.06±0.0001 mg g^{-1}, respectively. Also, the alkaloid content is very close to the result of 0.35±0.05-0.58±0.08% for *Treculia africana* seeds (0.35±0.05 to 0.58±0.08%) reported for *Treculia africana* seeds (Ijeh *et al.*, 2010). The tannin content is significantly larger than the value (0.21±0.02 mg 100 g^{-1}) for sweet potato leave (Antia *et al.*, 2006). The saponin content gotten in this study is lesser than the 6.0±0.06 mg 100 g^{-1} of *Punicagranatum*'s saponins (Dangogo *et al.*, 2011) and 18.7±0.31-19.9±0.67 mg 100 g^{-1} of *Solanumincanum* (*Auta et al., 2011*). Although, the values (0.13±0.03-0.37±0.03) reported for *Treculia africana* (Ijeh *et al.*, 2010) is was greater, however, the result shows that the foam dried watermelon flake has a very high flavonoid content for both temperatures than other phytochemical content (alkaloid, steroids, terpenoid, saponin, and tannins) considered in this study.

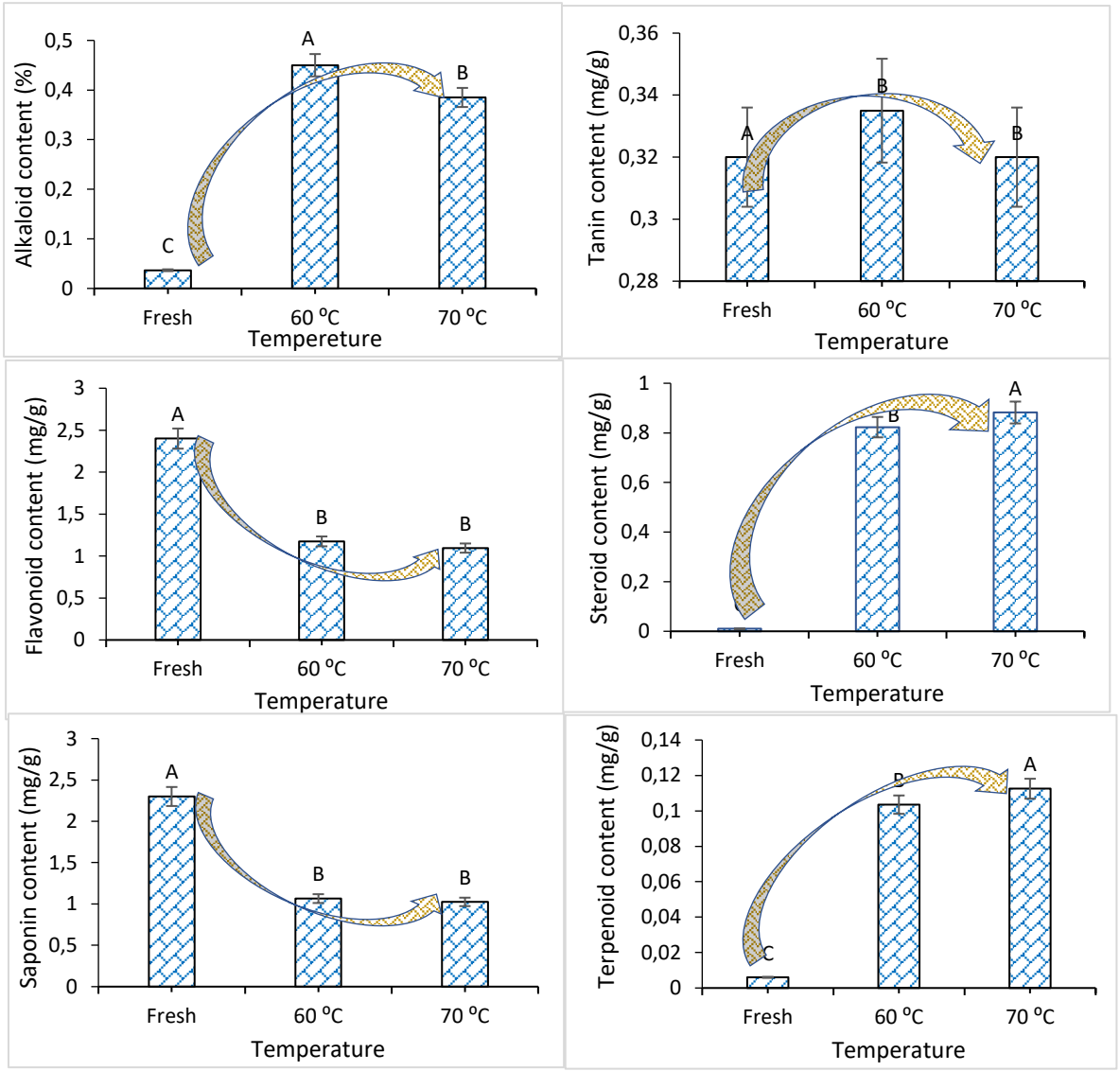

Figure 6. Phytochemical properties of fresh and dried watermelon: the column shows the magnitude of the content; the error bar denotes the standard deviation; the arrow shows the increment or decrement and bar with the same alphabet are not significantly different ($P<0.05$).

Antioxidant properties of watermelon

The antioxidant properties of fresh and foam-dried watermelon flakes at different temperature of 60 and 70°C was examined, and the result is sown in Figure 7. The result shows that ß-carotene(mg g^{-1}), lycopene(mg g^{-1}), total phenol (mgGAE g^{-1}), ABTS (ulEAC g-1), FRAP (mgAAE g^{-1}) and DPPH(%) were 1.30±0.00, 5.42±0.00 6.71±0.01, 20.17±0.24, 36.10±0.75, and 56±0.47 respectively for fresh watermelon, 9.55±0.007, 3.12±0.007, 8.57±0.47, 22.44±2.31, 38.73±0.90 and 54.22±1.12 respectively for temperature of 60ºC and 8.77±0.007, 3.23±0.014, 8.76±0.47, 15.7±2.31, 41.25±0.90 and 54.01±1.12 mg g^{-1} respectively for temperature of 70°C (Barba *et al.*, 2006), computed lycopene in various fruits and vegetables. They concluded that watermelon and tomatoes had the highest lycopene content. Charoensiri *et al.* (2009) looked at 37 different fruits and found red watermelon to be one of the best suppliers of lycopene. Perkins-Veazie *et al.* (2006) examined 50 different watermelon cultivars and found lycopene levels ranging from 3.52±2.30 to 11.20±2.0 mg 100 g^{-1}. Katherine *et al.* (2008) extracted 3.70 mg 100 g^{-1} of lycopene at 60°C and found a steady reduction when the

extraction temperature was increased up to 75°C. Other researcher also concluded that watermelon is a good source of lycopene (Oms-Oliu *et al.*, 2009; Liu *et al.*, 2012; Ambreen *et al.*, 2013). According to Johnson *et al.* (2013), the flesh of *Citrullus lanatus* is a good source of carotenoid (lycopene and carotene (pro-vitamin A)). However, -carotene in watermelon is considerably less abundant than lycopene. The level of ß-carotene in watermelon flakes, on the other hand, is larger than the content of lycopene, according to the findings of this study. When dried with a constant drying temperature. ß- Carotene which is another important carotenoid in watermelon is much lower in quantity compared to lycopene. According to Setiawan *et al.* (2001) the fresh flesh Citrullus lanatus is a good source of carotenoid, lycopene, and beta-carotene (provitamin A) (Liu *et al.*, 2012).

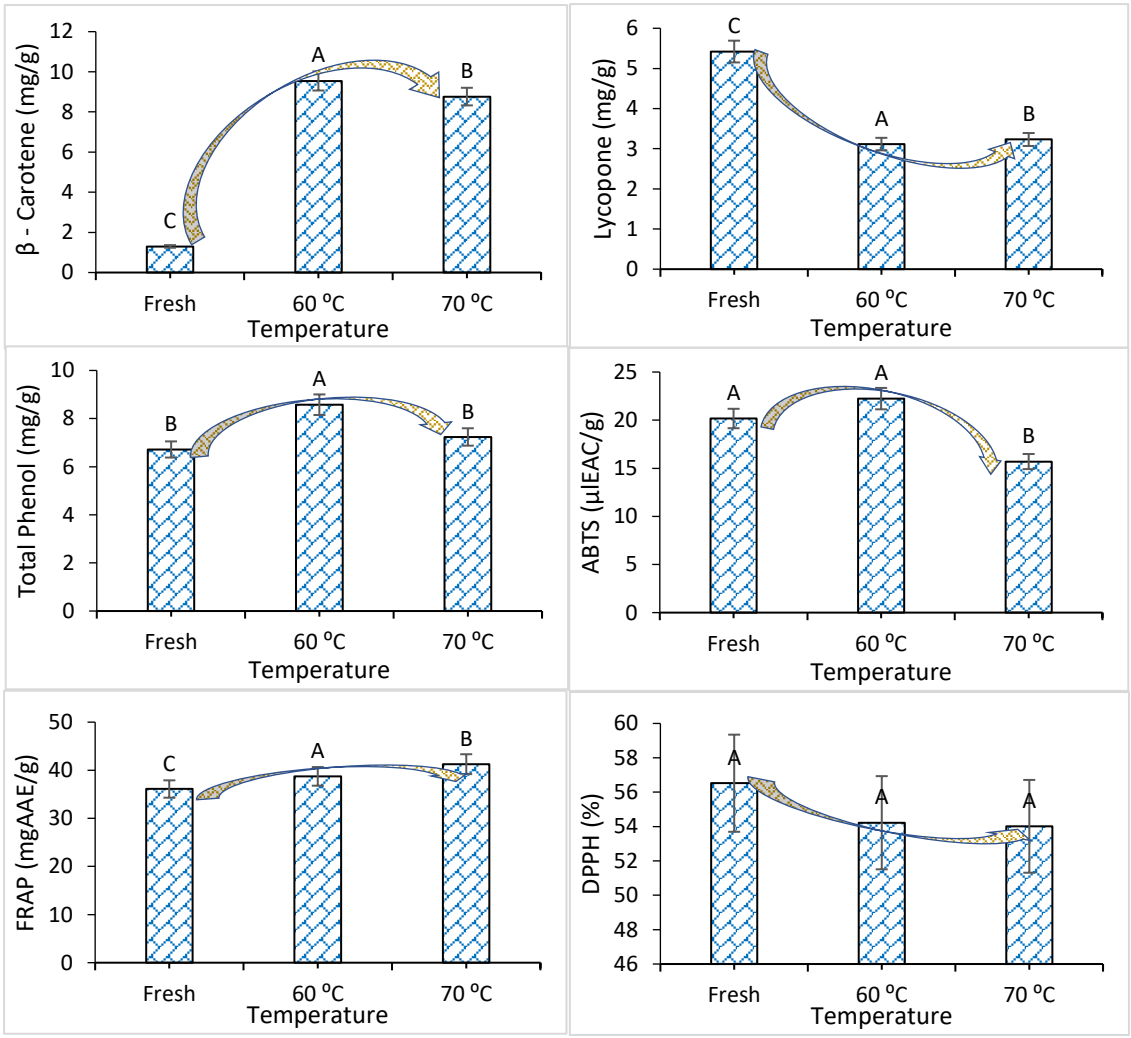

Figure 7. Antioxidant properties of fresh and dried watermelon: the column shows the magnitude of the content; the error bar denotes the standard deviation; the arrow shows the increment or decrement and any column with different alphabet are significantly different from one another at (P<0.05).

CONCLUSION

The findings of a research on foam-mat drying of watermelon pulp and quality estimation of evaluation of its flakes indicate the following:

i. The phytochemical properties of foam dried watermelon flakes which includes tannin, flavonoid, steroid, saponin, and terpenoid contents were found to be

0.34±0.021, 1.18±0.021, 0.82±0.001, 1.07±0.021, 0.10±0.004 mg g^{-1} respectively with alkaloid content of 0.45±0.014% for the drying temperature of 60ºC and 0.32±0.014, 1.09±0.007, 0.88±0.001, 1.03±0.021, 0.11±0.002 mg g^{-1} respectively, with alkaloid content of 0.39±0.007%, at drying temperature of 70ºC.

ii. The proximate composition of foam dried watermelon flakes was 3.98±0.021, 5.65±0.011, 4.06±0.063, 1.06±0.001, 3.51±0.014, 81.74±0.057% at constant drying temperature 60ºC and 4.44±0.014, 11.85±0.0008, 4.12±0.007, 1.12±0.000, 3.28±0.035, 75.2±0.019% at constant drying temperature 70ºC for the ash, fat, fibre, protein, and carbohydrates content, respectively.

iii. The antioxidant composition of foam dried watermelon which include ß - carotene, lycopene content total phenol, ABTS, FRAP, and DPPH were 9.55±0.007, 0.312±0.007, 8.57±0.47, 22.44±2.31, 38.73±0.90 and 54.22±1.12 mg g^{-1} respectively for drying temperature of 60°C and 8.77±0.007, 3.23±0.014, 8.76±0.47, 15.7±2.31, 41.25±0.90 and 54.01±1.12 mg g^{-1} respectively for drying temperature of 70°C.

iv. The foam dried watermelon flakes at temperature of 60°C contains 17.34±0.184, 71.07±100.31, 0.15±0.007, 1.66±0.002, 0.50±0.002, 0.77±0.001, 46.26±0.028 mg 100 g^{-1} and 13.24±0.028, 0.13±0.001, 0.96±0.004, 1.12±0.001, 0.53±0.003, 0.81±0.006, 47.35±0.021 mg 100 g^{-1} at drying temperature of 70°C for vitamin A, B1, B2, B3, B6, B12, and C respectively, and this shows that the qualities of the foam dried flakes were preserved and safe for consumption.

DECLARATION OF COMPETING INTEREST

The authors declare that he has no conflict of interests.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Authors declare the contributions to the manuscript such as the following sections:

John Isa: Conceptualization, visualization, ınvestigation and review of relevant literatures, methodology, data curation, validation, formal analysis, writing-original draft, review, and editing.

Ayoola Olalusi: Conceptualization, ınvestigation, methodology, review, and editing.

Olufunmilayo Omoba: Visualization, ınvestigation methodology, formal analysis, validation, review, and editing.

ETHICS COMMITTEE DECISION

This article does not require any ethical committee decision.

REFERENCES

Adedeji TO (2017). Development and quality evaluation of jam from watermelon (*Citrullus lanatus*) and pawpaw (*Carica papaya*) juice. *Archive Food Nutritional Science 1: 63-71.*

Adeolu AT and Enesi DO (2013). Assessment of proximate, mineral, vitamin and phytochemical compositions of plantain (*Musa paradisiaca*) bract-an agricultural waste. *International Research Journal of Plant Science, 4(7): 192-197.*

Akpinar EK, Bicer Y and Yildiz C (2006). Thin layer drying of red pepper. *Journal of Food Engineering, 59(1): 99-104.*

Akpinar EK and Bicer Y (2005). Modelling of the drying of eggplants in thin-layers. *International Journal of Food Science & Technology, 40(3): 273-281.*

Alam MH (2013). A Study on watermelon (*Citrullus lanatus*) juice preserved with chemical preservatives at refrigeration temperature. *Journal of Environmental Science and Natural Resources, 5(2): 23–28.*

Ambreen N Masood SB, Imran P and Nawaz H (2013). Antioxidant indices of watermelon juice and lycopene extract. *Pakistan Journal of Nutrition, 12(3): 255-260.*

Antia BS, Akpan EJ, Okon PA and Umoren IU (2006). Nutritive and anti-nutritive evaluation of sweet potatoes (*Ipomoea batatas*) leaves. *Pakistan Journal of Nutrition, 5(2): 166-168.*

AOAC (1995). AOAC Official Methods of Analysis (16th Edition). *Arlington, VA., USA.*

Arocho YD, Bellmer D, Maness N, Mcglynn W and Rayas-Duarte P (2012). Watermelon pomace composition and the effect of drying and storage on lycopene content and colour. *Journal of Food Quality, 35(5): 331-340.*

Arunachalam KD, Arun LB, Annamala SK, Annamalai SK and Arunachalam AM (2014). Potential anti-cancer properties of bio active compounds of *Gymnema sylvestre* and its bio functionalized silver nanoparticles. *International Journal of Nanomedicine, 10: 31-41.*

Auta R, James SA, Auta T and Sofa EM (2011). Nutritive value and phytochemical composition of processed (*Solanum aethiopicum*) Bitter garden egg. *Science World Journal, 6: 5-6.*

Barba AO, Hurtado MC, Mata MS, Ruiz VF and Tejada ML (2006). Application of a UV–vis detection-HPLC method for a rapid determination of lycopene and b-carotene in vegetables. *Food Chemistry, 95(2): 328–336.*

Berry RE, Wagner CJ, Bissett OW and Veldhuis MK (1972). Preparation of instant orange juice by foam-mat drying. *Journal of Food Science, 37: 803-808.*

Berry R, Bissett O and Lastinger J (1965). Methods for evaluating foams from citrus concentrates. *Food Technology, 19(7): 144-147.*

Brunner J (1984). Direct spectrophotometer determination of saponin. *Analytical Chemistry, 34: 1314-1326.*

Cakmak H (2020). Evaluation of foam-mat drying behaviour of crab apple (*Malus floribunda*) fruit juice and powder quality. *Journal of Food,45(3): 530-543.*

Charoensiri R, Kongkachuichai R, Suknicom S and Sungpuag P (2009). Beta-carotene, lycopene, and alpha-tocopherol contents of selected Thai fruits. *Food Chemistry, 1132: 202-207.*

Chaux-Gutiérrez AM, Adriana BS, Granda-Restrepo DM and Maria AM (2017). Foam mat drying of mango: Effect of processing parameters on the drying kinetic and product quality. *Drying Technology, 35(5): 631-641.*

Colla G, Rouphael Y, Cardarelli M, Massa D, Salerno A and Rea E (2006). Yield, fruit quality and mineral composition of grafted melon plants grown under saline conditions. *The Journal of Horticultural Science and Biotechnology, 81(1): 146-1522.*

Dangoggo SM, Muhammad AI, Tsafe AA, Aliero AA and Itodo AU (2011). Proximate, mineral and anti-nutrient composition of *Gardenia aqualla* seeds. *Arch. Applied Science Resources, 3(4): 485-492.*

Egbuonu AC (2015). Assessment of some antinutrient properties of the watermelon (*Citrullus lanatus*) rind and seed. *Research Journal of Environmental Sciences. 9(5): 225-232.*

Egwaikhide PA and Gimba CE (2007). Analysis of the phytochemical content and antimicrobial activity of *Plectranthus glandulosis* whole plant. *Middle-East. Journal of Scientific Research, 2(3-4): 135-138.*

FAOSTAT (2008). Crops. FAOSTAT. Food and agriculture organization of the United Nations (Database). Retrieved from http://faostat.fao.org/site/567/default.aspx#ancor

Figueroa A, Sanchez-Gonzalez MA, Wong A and Arjmandi BH (2012). Watermelon extract supplementation reduces ankle blood pressure and carotid augmentation index in obese adults with prehypertension or hypertension. *American journal of hypertension, 25: 640-643.*

Fila WA, Ifam EH, Johnson JT, Odey MO, Effiong EE and Dasofunjo KA (2013). Comparative proximate compositions of watermelon *Citrullus lanatus*, *Squash cucurbita* pepo'l and Rambutan, *Nephelium lappaceum, 2(1): 81-88.*

Fish WW and Davis AR (2003). The effects of frozen storage conditions on lycopene stability in watermelon tissue. *Journal of Agricultural and Food Chemistry, 51(12): 3582-3585.*

Franco TS, Perussello CA, Ellendersen LN and Masson ML (2015). Effect of process parameters on foam mat drying kinetics of yacon (*Smallanthus sonchifolius*) and thin-layer drying modeling of experimental data. *Journal of Food Process Engineering, 40(1): 12264-12273.*

Gin WA, Jimoh A, Abdulkareem AS and Giwa A (2014). Production of activated carbon from watermelon peel. *International Journal of Scientific Enginering andResearch, 5(2): 66-71.*

Ginnette LE, Graham RP, Miers JC and Morgan JA (1963). Tomato powder by foam-mat drying. *Food Technology, 17(6): 133-135.*

Hart M, Graham R, Ginnette L and Morgan JA (1963). Foams for foam-mat drying. *Food Technology, 17(10): 90-92.*

Ijeh I, Ejike CE, Nkwonta OM and Njoku BC (2010). Effect of traditional processing techniques on the nutritional and phytochemical composition of African bread-fruit (*Treculia africana*) Seed. *Journal of Applied Sciences and Environmental Management,14(4): 169-173.*

Inuwa HM, Aina VO, Gabi BI., Aimola I and Thompson, V. (2011). Determination of differences in nutrient composition of *Citrullus vulgaries* (watermelon) fruits after plucking. *British Journal of Dairy Sciences, 2(2): 27-30.*

Isa J and Olalusi AP (2019) Optimization of foam-mat drying process of watermelon pulp using response surface methodology. *Journal of Energy Research and Reviews 3(1): 1-11.*

Jagtiani HT, Chan J and Sakai WS (1988). Tropical fruit processing. In Food Science and Technology. *London: Academic Press Inc.pp. 9-43.*

Javed IM, Aleem A, Hamad R, Furqan NM and Ammad R (2018) A review paper on foam-mat drying of fruits and vegetables to develop powders. *MOJ Food Process Technol. 6(6): 465–467.*

Jeffrey C (2001). Cucurbitaceae. In Mansfeld's Ornamentals (pp. 1510-1557). *Germany: Springer, Berlin.*

Johnson JT, Iwang EU, Hemen JT, Odey MO, Effiong EE and Eteng OE (2013). Evaluation of anti-nutrient contents of watermelon A. *Annals of Biological Research, 3(11): 5145-5150.*

Katherine LS, Edgar CC, Jerry WK, Luke RH and Carrier DJ (2008). Extraction conditions affecting supercritical fluid extraction (SFE) of lycopene from watermelon. *Bioresource Technology, 99(16): 7835-7841.*

Lakshmi AJ and Kaul P (2011). Nutritional potential, bioaccessibility of minerals and functionality of watermelon (*Citrullus vulgaris*) seeds. *LWT-Food Science Technology, 44(8): 1821-1826.*

Liu C, Zhang H, Dai Z, Liu X and Liu Y (2012). Volatile chemical and carotenoid profiles in watermelons [*Citrullus vulgaris* (Thunb.) and Schrad (Cucurbitaceae)] with different flesh colors. *Food Science and Biotechnology, 21(2): 531-541.*

Makkar HP (1996). Quantification of tannins: a laboratory manual. *Aleppo, Syria.: ICARDA.*

Morgan A, Graham R, Ginnette L and Williams G (1961). Recent developments in foam mat drying. *Food Technology, 15: 37-39.*

Munawar N, Najjah A, Nur SR, Norhayati H (2020). Characterization of watermelon rind powder using foam mat drying with different types of foaming agents and temperatures. *Asian Journal of Fundamental and Applied Sciences, 1(3): 1-10.*

Nagaski M (2006). *Phytochemical screening and proximate analysis of cassiasiamea leaves*. M.Sc. Dissertation. Sokoto: Postgraduate School, Usman Danfodiyo University Sokoto.

Njoku VO and Obi C (2009). Phytochemical constituents of some selected medicinal plants. *African Journal of Pure and Applied Chemistry, 3(2): 228-233.*

Noordia A, Yetty SM and Nining WK (2020) Foam mat drying of banana juice: varieties of ripe banana analysis and egg albumen foam. *Food Science and Technology, Campinas, 40(2): 465-468.*

Oms-Oliu G, Odriozola-Serrano I, Soliva-Fortuny R and Belloso OM (2009). Use of Weibull distribution for describing kinetics of antioxidant potential changes in fresh-cut watermelon. *Journal of Food Engineering, 95(1): 99-105.*

Ornamentals JC (2001). Cucurbitaceae. In H. P (Ed.), Mansfeld's (Vol. 3, pp. 1510-1557). *Berlin, Germany: Springer.*

Oseni OA and Okoye VI (2013). Studies of phytochemical and antioxidant properties of the fruit of watermelon (*Citrullus lanatus*). *Journal of Pharmaceutical and Biomedical sciences, 27(27): 508-514.*

Parmar HS and Kar A (2009). Protective role of *Mangifera indica*, *Cucumis melo* and *Citrullus vulgaris* peel extracts in chemically induced hypothyroidism. *Chemico-Biological Interactions, 177(3): 254-258.*

Perkins-Veazie P, Collins, JK, Pair SD and Roberts W (2006). Lycopene content differs among red-fleshed watermelon cultivars. *Journal of the Science of Food and Agriculture, 81: 983-987.*

Proietti SR, De Agazio M, Zacchini M, Rea E, Moscatello S and Battistelli A (2008). Fruit quality of mini-watermelon as affected by grafting and irrigation regimes. *Journal of the Science of Food and Agriculture, 88: 1107-1114.*

Robinson RW and Decker-Walteri DS (1997). Cucurbits. *CAB International Wallingford, UK., 226.*

Sadler G, Davis J and Dezman D (1990). Rapid extraction of lycopene and b -carotene from reconstituted tomato paste and pink grapefruit homogenates. *Journal of Food Science, 55: 1460–1461.*

Sadler G, Davis J and Dezman D (1990). Rapid extraction of lycopene and ß-carotene from reconstituted tomato paste and pink grapefruit homogenates. *Journal of Food Science, 55: 1460-1461.*

Setiawan B, Sulaeman A, Giraud D and Driskell J (2001). Carotenoid content of selected Indonesian fruits. *Journal of Food Composition Analysis, 14(2): 169-176.*

Shivani A, Verma K, Sharma PC, Anil G and Manisha K (2019) Effect of foaming agent on quality and yield of foam mat dried papaya powder. *International Journal of Currently Microbiology and Applied Science, 8(12): 2821-2835*

Shofian N, Hamid A, Osman A, Saari N, Anwar F, Pak DM and Hairuddin M (2011). Effects of freeze-drying on the antioxidant compounds and antioxidants activity of selected fruits. *International Journalof Molecular Sciences, 12(7): 4678-4692.*

Siddiqui M, Ravi R, Harte JB and Dolan KD (2010). Physical and functional characteristics of selected dry bean (*Phaseolus vulgaris* L.) flours. *Journal of Food Science and Technology, 43: 232–237.*

Simmonds NW (1976). Evolution of Crop Plants. *London: Longman.*

Snowdon AL (1990). Quality of fruit and vegetable. In color atlas of postharvest (pp.207-209). *Blackwell Publishing.*

Sodipo OA, Akiniyi JA and Ogunbamosu JU (2000). Studies on certain characteristics of extracts of bark of *Pausinystalia johimbe* and *Pausinystalia macroceras* (K Schum) Pierre ex Beille. *Global Journal of Pure Applied Science, 6: 83-87.*

Sofowora A (1993.). Medicinal Plants and Traditional Medicinal in Africa. *In Screening Plants for Bioactive* Agents; p. 134-156. Ibadan: 2nd Ed. Sunshine House, *Spectrum Books Ltd.*

Sundia (2007). Watermelon production and consumption demographics. *Sundra Corporation, 35-40.*

Tindall HD (1991). Growing Commercial Vegetable. *National College of Agricultural Engineering.*

Togrul IT and Pehlivan D (2004). Modeling of thin layer drying kinetics of some fruits under open air sun drying process. *Journal of Food Engineering, 65(3): 413-425.*

USDA (U.S Dept. Agr.). (n.d.). Nutritional Composition of Watermelon. Retrieved from http://watermelon.ifas.ufl.edu/Uses_and_Nutritional_Composition.html

USDA (2010). USDA national nutrient database forstandard reference, release 23. Nutrient Data Laboratory HomePage. Retrieved January 15, 2015, from e http://www.ars.usda.gov/ba/bhnrc/ndl

Van der Vossen HAM, Denton OA and El-Tahir IM (2004). *Citrillus lanatus*. In: Grubben, G. J. H andDenton, O. A. Plant resources of Tropical Africa 2 Vegetables. Wageningen. The Netherlands; CTA, Leiden, the Netherlands: *Backhuys Publishers*, p. 185-191.

Wasylikowa K and Var de Veen M (2004). An archaeobotanical contribution to the history of watermelon, *Citrullus lanatus* (Thunb.) Matsum and Nakai (syn. *C. vulgaris* Schrad.*). Vegetation. History Archaeobotany, 13: 213-217.*

Yau EW, Rosnah S, Noraziah M, Chin NL and Osman H (2010). Physico-chemical compositions of the red seedless watermelons (*Citrullus lanatus*). *International Food Research Journal, 17(2): 327-334.*

Zhu M, Philipson TD, Greengrass PM, Bowmey R and Cal T (1997). Plant polyphenols: biologically active compounds or non-selective binders to protein. *Phytochemistry, 44(3): 441-447.*