



ORIGINAL RESEARCH ARTICLE

EFFECTS OF DRYING TEMPERATURES ON NUTRITIONAL AND PHYTOCHEMICAL PROPERTIES OF GONGRONEMA LATIFOLIUM LEAVES

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ABSTRACT

This study investigated the effects of drying temperature on the nutritional and phytochemical components of *Gongronema latifolium* (Bush Buck) leaves; a widely spread edible indigenous leafy vegetable of West Africa. The leaves were dried at room temperature (RTD), in the open sun (OSD) and at 30, 40, 50, 60 and 70 °C in a convective oven (OD). Proximate and phytochemical analyses were done on the products of each OD temperatures, while for RTD and OS drying, the tests were done at their equilibrium moisture content (M_i) of the ambient. Statistical analysis was done using MATLAB. The parameters of the fresh leaves with 82.95% moisture content served as the control. Drying decreased the product M_i to 12.95%, 7.65%, 6.95%, 5.79% and 5.03% in the listed order of the drying temperatures. The proximate and phytochemical contents increased with drying temperature. 70 °C drying temperature gave the highest contents of ash (16.35%), fibre (27.85%), protein (22.70%), carbohydrate (32.84%) and fat (2.42%) in the dried leaves. Same went for the phytochemicals: alkaloid (4.50%), flavonoid (3.92%), saponin (1.46%), tannin (1.39%) and terpenoids (2.72%). Second order polynomial models fitted the data well and gave coefficient of determination (R^2) of 0.789 for fibre, 0.869 for fat, 0.895 for protein, 0.921 for ash, 0.923 for terpenoids, 0.941 for moisture, 0.943 for flavonoids, 0.982 for saponins, 0.987 for alkaloids and 0.992 for tannins content. These results show that there are strong relationships between the proximate and phytochemical composition and the drying temperatures. At their corresponding temperatures, OSD yielded the highest value of saponins (1.45%), tannins (0.64%) and terpenoids (2.45%), RTD gave highest value of alkaloids, flavonoids, carbohydrate (58.38%), protein (17.07%) and fat (1.10%), while OD yielded the highest fibre content (28.32%). The results show that drying methods and conditions should be chosen based on the intended use of the products.

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1.0 Introduction

Reports have shown that vegetables provide bulk fibre, which aids digestion and are good sources of vitamins and minerals like ascorbic acid, beta carotene, riboflavin, Calcium, Magnesium, Iron and Phosphorus in the human diet (Mohammadu et al., 2014 and Lawal et al., 2015). They have also been used from time as spices in food, condiments and for medicinal purposes like other plant materials (Nweze and Eze, 2009 and Rhoda and Negimote, 2015). The Igbo tribe of South-Eastern Nigeria employs *Ocimum gratissimum* in the management of the neonatal umbilicus, the coastal areas of Nigeria for the treatment of epilepsy, high fever and diarrhea, and the Savannah areas apply it for treating mental illness and to keep wound surfaces sterile (Ijeh et al., 2004, Njoku et al., 2011a, b and Rhoda and Negimote, 2015). Some species of leafy vegetables are known to contain such phytochemicals as alkaloids, saponins, terpenoids, flavonoids, tannins, phlobatannins, anthraquinones, steroids and cardiac glycosides, which make them useful in the treatment of fungal infections, cold and catarrh (Molyneux et al., 2007, Oladosu-Ajayi et al., 2017 and Mbegbu et al., 2021).

Gongronema latifolium is a tropical rainforest plant which belongs to the family Asclepiadaceae and genus *Gongronema* (Okafor, 2002) and is valued for its leaves (Eleyinmi, 2007). It grows in West Africa and is known

among the Nigerian ethnic groups as “Utasi” by the Ibibios, Quas and Efik; “Utazi” by the Igbos and “Arokeke” by the Southwestern Yorubas. In Ghana and Senegal, the plant is referred to as “Akan-Asante aborode” and “Sever gasule” respectively (Balogun et al., 2016). *Utazi* is also found in some other West African and tropical countries (Balogun et al., 2016), including Guinea-Bissau, Cameroon (West) and Sierra Leone (Owu et al., 2012). It is a climbing edible plant with a pliable stem, yellow flower and green leaf that produces milky latex when plucked. It has a characteristic sharp, bitter and slightly sweet taste, especially when eaten fresh (Okafor, 1987). The leaf is rich in fats (16%), fibre (6.3%), ash (1.3%), proteins (33.2%), carbohydrate (43.7%) and essential amino acids. (Eleyinmi, 2007 and Alobi et al., 2012). *Utazi* leaf is commonly used fresh in some traditional soups as vegetable, or dried and employed as powdery spice. It is also consumed raw (fresh from harvest) and can be used in salad preparations (Balogun et al., 2016). The root and stem are used as chewing stick in Sierra Leone. In addition to the nutritional uses, *G. latifolium* is also used for medicinal purposes based on its perceived phytochemicals content. A liquor from aqueous extract of the leaves or from boiling it with lime juice is used for treating colic, stomach pains and symptoms of worm infestation, and as a purgative (Okafor, 2002). Iwu (2014) reported hypoglycemic, antioxidant and anti-inflammation activities of *Utazi* from scientific studies. Ethanol extracts of *G. latifolium* gave analgesic, anti-pyretic and anti-ulcer benefits in laboratory rats experiments (Akuodor et al., 2016).

Although this plant is drought-tolerant, it is not available in the dry season. Since vegetables are perishable products due to their high moisture contents; 60.0 - 98.8% (Njoku et al., 2011b), they are usually dried and stored. Drying of vegetable materials is a necessary option for both storage and handling purposes. Drying reduces water activity, leads to significant reduction in weight and volume, and consequently reduces costs of packaging, transportation and storage (Khaled et al., 2014). Reduced moisture content also hinders biochemical activities of spoilage agents on food substances (Alegbeleye et al., 2022). However, drying also alters other physical, biological and chemical properties of foods (Njoku et al., 2011a). Hot-air drying is a very common preservation method used in treating foodstuffs for preservation of the qualities of the products (Oladosu-Ajayi et al., 2017). In thin layer hot-air drying, falling rate period which starts after the critical point is achieved when the droplet surface becomes unsaturated. The period is marked by the phenomenon wherein the volatile solvent's internal transfer to the product surface controls the drying rate. Rapid fall of the drying rate ensues beyond this period, with a rise in the surface temperature of the product (Mbegbu et al., 2021).

The importance of *Utazi* in the rainforest zone of West Africa notwithstanding, little published studies is available on the effect of drying on the phytochemical and proximate components. Consequently, there is need for studies on drying of its leaf to properly understand the effects of drying temperatures on its nutritional and phytochemical composition. Information from the study will help our local food vendors and food scientists on the best drying temperatures for the leaf under tropical conditions, and in the post-harvest processing and handling. Therefore, the objective of this study is to determine the effect of drying temperatures on the proximate and phytochemical compositions of *Gongronema latifolium* (*Utazi*) leaf.

2. Materials and Method

Fresh leaf samples of *Gongronema latifolium* (*Utazi*) were purchased from Nsukka market (latitude 6.8518°N, longitude 7.4014°E) and taken immediately to the crop science laboratories of the University of Nigeria Nsukka, for identification. The leaves (see sample in Plate 1) were detached from the stems and washed thoroughly.

The initial and final moisture contents of the samples were determined before and after each drying run, by gravimetric method. The method used involves oven drying at 105 °C for 24 hours as described by the Association of Official Analytical Chemists (AOAC, 1990). Three samples of 30 g each of the leaves were dried in an oven under these conditions until there was no further weight reduction. The moisture content was determined in percent dry basis (%db) using Equation 1.

$$M_t = \frac{m_w - m_d}{m_d} \quad 1$$

where, M_t is the moisture content (g water/g dry matter) at time, t , m_w is the wet mass of sample (g) and m_d is the dry mass of the sample (g).



Plate 1: A fresh *Gongronema latifolium* leaf

2.1 Experimental Procedure

A laboratory vacuum oven dryer (Faithful Oven DZ-3BE, China) with specifications; 220 V, 50 Hz and 2000 W, 10–250 °C operating temperature and <133 Pa operating vacuum, was used for the drying experiments. The oven temperature was set at 30 °C, 40 °C, 50 °C, 60 °C and 70 °C for the different experimental runs and allowed to equilibrate before loading the samples. Following the method used by Arslan and Özcan (2012) and Mbegbu *et al.* (2021), fresh samples of *Utazi* leaves were uniformly distributed in a thin layer on the dryer trays constructed with chicken mesh material. The experiments were conducted in three replicates for each oven temperature. The samples were periodically weighed with the drying tray made of chicken mesh to avoid buoyancy effect between the warm pan and the wide leaves when placed on the weighing balance. The drying process was continued until at least two consecutive masses of the dry samples were observed to be constant. At the end of each drying run, the sample mc, nutritional and phytochemical content were determined in the laboratory.

The laboratory tests made on the samples were restricted to proximate and phyto-chemical analyses. The proximate analyses carried out were moisture, ash, crude protein, crude fibre and carbohydrate contents, while the phyto-chemical analyses carried out were for alkaloid, flavonoid, saponin, tannin and terpenoid contents. The procedures used are described in detail in the references provided in the following sections.

2.1.1 Phytochemical analysis

Phytochemical analysis was conducted according to methods described by Yadav and Agrawala (2011), Patle *et al.* (2020) and AOAC (1990). Quantitative phytochemical determination for Alkaloids, Flavonoids, Cardiac glycosides and Phenols were carried out according to methods described by Edeoga *et al.* (2005).

2.1.2 Proximate analysis

Proximate composition of leaves for carbohydrate, ash, and moisture were determined by methods described by AOAC (2006). Crude protein, fibre and fat content were determined by methods described by Oyeyemi *et al.* (2017). Total ash content was determined by furnace incineration as reported by Antia *et al.* (2006).

2.2 Data and Analysis

The drying models were obtained by fitting the transformed drying data into two thin layer drying models using MATLAB software. The reason for the transformation is to make the data free from dimensional disparities by converting the moisture content to moisture ratio. The expression for achieving this is presented in Equation 2.

$$\text{Moisture Ratio (MR)} = \left(\frac{M_t - M_i}{M_o - M_i} \right) \quad 2$$

where, M_t is the moisture content (mc) of the product at time t , M_o the initial mc of the product and M_i the equilibrium mc. The values of M_c are relatively small compared to M_t and M_o .

Statistical analysis such as coefficient of determination (R^2), Error mean Square (EMS), and Root mean square error (RMSE) was used to show how well the models fitted the data considering the values of the parameters shown in Equations 3 to 5.

$$R^2 = 1 - \left[\frac{\sum_{i=1}^N (MR_{pre,i} - MR_{exp,i})^2}{\sum_{i=1}^N (MR_{pre,i}^2 - MR_{exp,i}^2)} \right] \quad 3$$

$$RMSE = \left(\frac{1}{N} \sum_{i=1}^N [MR_{pre,i} - MR_{exp,i}]^2 \right)^{\frac{1}{2}} \quad 4$$

$$SSE = \sum_{i=1}^N (MR_{exp,i} - MR_{pre,i})^2 \quad 5$$

To determine the relationships between the phytochemical and proximate quantities, the data were regressed against the drying temperatures by second order polynomial models. The goodness of fit was estimated by the corresponding coefficient of determination, R^2 , which varies from 0.0 to 1.0. The higher the R^2 value, the better the relationship between the factors and response variables in the models (Turan and Firatligil, 2019). The result was presented in the forms of tables and charts.

3. Results and Discussion

3.1 Moisture Content

The initial moisture content of *Gongronema latifolium* leaf was 82.95%db. Figure 1 shows the moisture content (dry basis) of the dried *Utazi* leaves for the various drying temperature. At each drying temperature, the drying rate of the sample decreased until it attained equilibrium with the drying air. At 30 °C, 40 °C, 50 °C, 60 °C and 70 °C the corresponding equilibrium moisture contents were 12.95%, 7.65%, 6.95%, 5.79% and 5.03% respectively. Increasing drying temperatures resulted in lower sample equilibrium moisture content (M_i). Alakali et al. (2015) reported a 15.01 - 2.50% mc for dried *Moringa oleifera* leaves at 30 - 70 °C drying temperatures. Mbegbu et al. (2021) obtained 0.2% and 0.1% product mc after 6.5 hrs and 5.5 hrs drying of scent leaf and lemon basil leaves respectively.

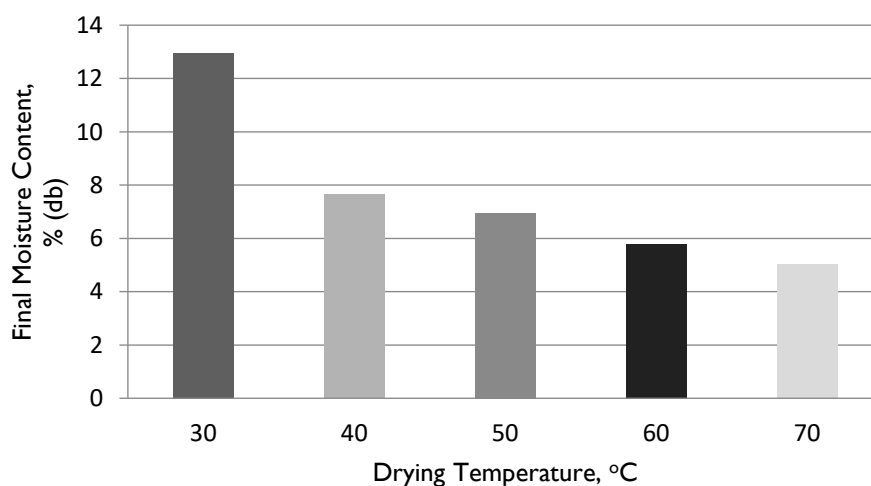


Figure 1: Moisture content versus drying temperatures at equilibrium

3.2 Drying Characteristics

The drying characteristics of the materials were investigated by converting the drying data moisture ratio and plotted it against the drying time. The curve fitting identified the Logarithmic and Two-term diffusion models as the most adequate for the drying data and therefore were used for the predictive models for *Gongronema latifolium* leaves. Figure 2 shows the plot the moisture ratio against drying time. From the figure, there was a decrease in the time required to dry the leaves to M_i as the drying temperature increased. For 30 °C drying temperature it took 6 hrs to reduce the initial moisture content to the 12.95%db M_i , with the falling rate

period endpoint occurring at 2 hrs 30 mins. At 40 °C drying, the leaves were dried to 7.65%db M_i in 4 hrs, with the falling rate period ending in 2 hrs. 50, 60 and 70 °C drying temperatures gave 6.95%db, 5.79%db

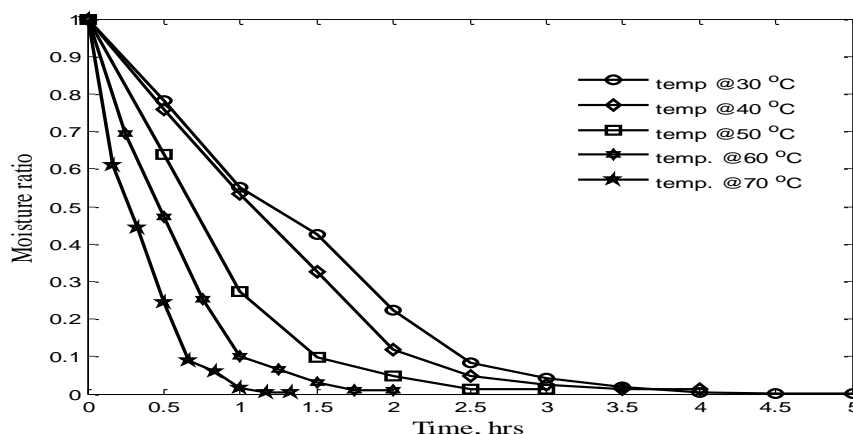


Figure 2: Plot of moisture ratio against drying time

and 5.03%db M_i in 3 hrs, 2 hrs and 1 hr 20 mins, with 1 hr 30 mins, 1 hr and 39 mins falling rate period end points respectively. The drying was observed to take place majorly during the falling rate period. Table I contains the drying model equations and their parameters and goodness of fit. The drying was well predicted with exponential models with R^2 values of 0.8345 - 0.9973. Thus at 95% confidence interval (CI), the

Table I: The drying model parameters of *Gongronema latifolium* leaves

Temp. (°C)	Model	Model constants				Goodness of fit		
		A	K_1	B	K_2	R^2	SSE	RMSE
30	$MR = A \cdot \exp(k_1 \cdot t) + B \cdot \exp(k_2 \cdot t)$	5.458	-2.027	-5.458	-2.027	0.9896	0.01321	0.04344
	$MR = A \cdot \exp(k \cdot t)$	0.1596×10^4	-1.257	--	--	0.9726	0.03462	0.06202
40	$MR = A \cdot \exp(k_1 \cdot t) + B \cdot \exp(k_2 \cdot t)$	-2172	-1.651	2173	-1.65	0.9942	0.006336	0.0356
	$MR = A \cdot \exp(k \cdot t)$	1.06	-0.8562	--	--	0.9698	0.0329	0.06855
50	$MR = A \cdot \exp(k_1 \cdot t) + B \cdot \exp(k_2 \cdot t)$	1.109	-2.430	0	-2.43	0.8345	0.1448	0.2197
	$MR = A \cdot \exp(k \cdot t)$	1.033	-1.280	--	--	0.9827	0.01512	0.0550
60	$MR = A \cdot \exp(k_1 \cdot t) + B \cdot \exp(k_2 \cdot t)$	-1452	-3.28	1453	-3.278	0.9973	0.002782	0.02359
	$MR = A \cdot \exp(k \cdot t)$	0.1609	-1.2750	--	--	0.9858	0.01443	0.0454
70	$MR = A \cdot \exp(k_1 \cdot t) + B \cdot \exp(k_2 \cdot t)$	-704.8	-4.538	705.8	-4.535	0.9930	0.006715	0.03665
	$MR = A \cdot \exp(k \cdot t)$	1.0138	-2.981	--	--	0.9891	0.01047	0.03867

models can predict the drying data well with minimal error. The best prediction was obtained for 60 °C drying, while the worst was for 50 °C. Mbegbu et al. (2021) reported the logarithm model as the best for predicting scent leaf and lemon basil leaf drying under similar experimental conditions, with R^2 values of 0.9998 and 0.9961 respectively. Falling rate period was also predominant for drying their two leaves. Logarithmic and Page models were reported by Turan and Firatligil (2019) as the best for predicting the drying process kinetics of thyme leaves dried at 50, 60, 70 and 80 °C.

3.3 Phytochemicals Presence

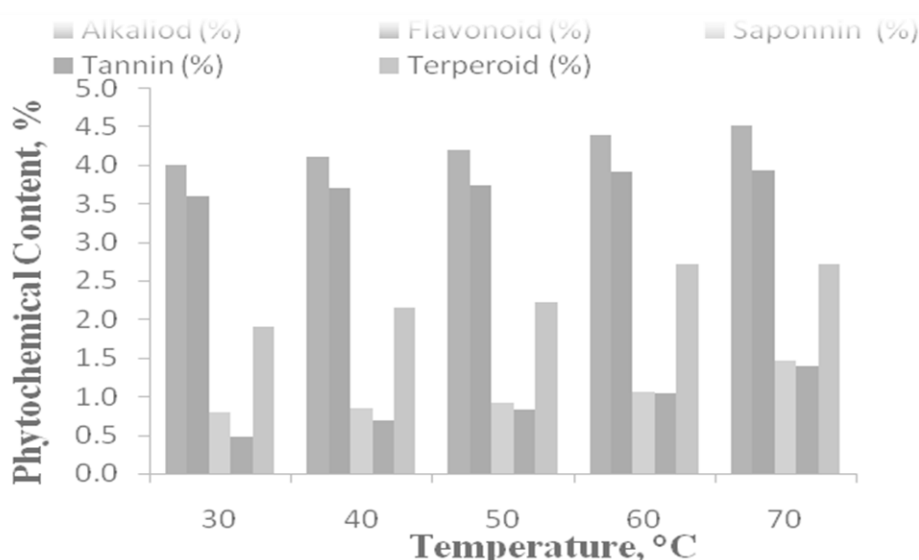
The phytochemical analysis for the dried *Utazi* leaf is shown in Table 2. The presence of a phytochemical in the dried leaves was indicated with a + sign while its absence was indicated with a – sign. Only the significant components were further investigated. The results showed the dried leaves contain alkaloids, saponins, flavonoids, and tannins in significant amount, while cardiac glycosides, anthraquinones, deoxy sugar and phlobatannins were not in significant amount. Other phytochemicals detected were terpenoids, phenol and carbohydrates.

Table 2: Preliminary analysis for phytochemical constituents of *Utazi* leaves

S/N	Phytochemicals	Presence
1.	Alkaloids	+
2.	Saponin	+
3.	Flavonoids	+
4.	Tannins	+
5.	Terpenes	+
6.	Cardiac glycosides	-
7.	Phenol	+
8.	Carbohydrates	+
9.	Anthraquinones	-
10.	Deoxy sugar	-
11.	Phlobatannins	-

3.4 Phytochemical Content

Figure 3 shows the phytochemical contents of the dried *Utazi* leaves for various drying temperatures. Leaves dried at 30 °C have alkaloids, saponins, flavonoids, tannins and terpenoids contents of 4.0%, 3.6%, 0.8 %, 0.5% and 1.9% respectively. The leaves dried at 40 °C have 4.1%, 3.7%, 0.8% and 0.7% and 2.1% of alkaloids, saponins, flavonoids, tannins and terpenoids contents respectively. For 50 °C drying temperature, the alkaloids, saponins, flavonoids, tannins and terpenoids contents were 4.2%, 3.7%, 0.9%, 0.8% and 2.2% respectively. 60 °C drying temperature gave leaves of 4.4%, 3.9%, 1.0%, 1.0% and 2.7% alkaloids, saponins, flavonoids, tannins and terpenoids contents respectively. The alkaloids, saponins, flavonoids, tannins and terpenoids contents were 4.5%, 3.9%, 1.5%, 1.4% and 2.7% for leaves dried at 70 °C. There was gradual steady increase in all the phytochemicals with increasing drying temperature, showing the concentration of the substances with increasing dehydration. For all the drying temperatures considered, the alkaloids had the highest concentration followed by the flavonoids, while the tannins had the least. The saponins was second least in concentration but had more gradual relative increase than the tannins with increasing temperature. The alkaloids and the flavonoids also had the least relative increase in concentration. The terpenoids were average both in content and relative increase in concentration. This could probably mean that the degradation of these phytochemicals with increasing temperature during convective hot-air drying of *Utazi* leaves increases in the order; tannins - saponins - terpenoids - flavonoids - alkaloids. Shi *et al.* (2004) reported that an optimum thermal process can increase the stability and maintain the saponins in processed products.

**Figure 3:** Phytochemical contents versus drying temperatures

3.5 Other Nutritional Content

The percentage nutritional compositions of *Utazi* leaves dried at various temperatures are presented in Figure 4. The results show that the leaves dried at 30 °C had percentage of ash, fibre, protein, carbohydrate and fat contents observed to be 13.25%, 28.32%, 16.83%, 27.70% and 0.95% respectively. Equally, when the leaves

were dried at 40 °C, the percentage of the constituents were 15.32%, 23.02%, 20.89% and 27.66% and 1.96% for ash, fibre, protein, carbohydrate and fat contents respectively. For 50 °C drying temperature, the ash, fibre, protein, carbohydrate and fat contents were 15.42%, 24.91%, 21.21%, 28.95% and 2.04% respectively. 60 °C drying temperature gave leaves of 16.05%, 28.28%, 21.62%, 32.48% and 2.07% ash, fibre, protein, carbohydrate and fat contents respectively. The ash, fibre, protein, carbohydrate and fat contents were 16.35%, 30.33%, 22.70%, 32.84% and 2.42% for leaves dried at 70 °C. Similar trend was reported by Alakali (2015) for nutrient contents of dried *Moringa oleifera* leaves at 30 - 70 °C drying temperature. Negi *et al.* (2001) observed better quality parameters retention for leafy green vegetables dried under faster drying conditions.

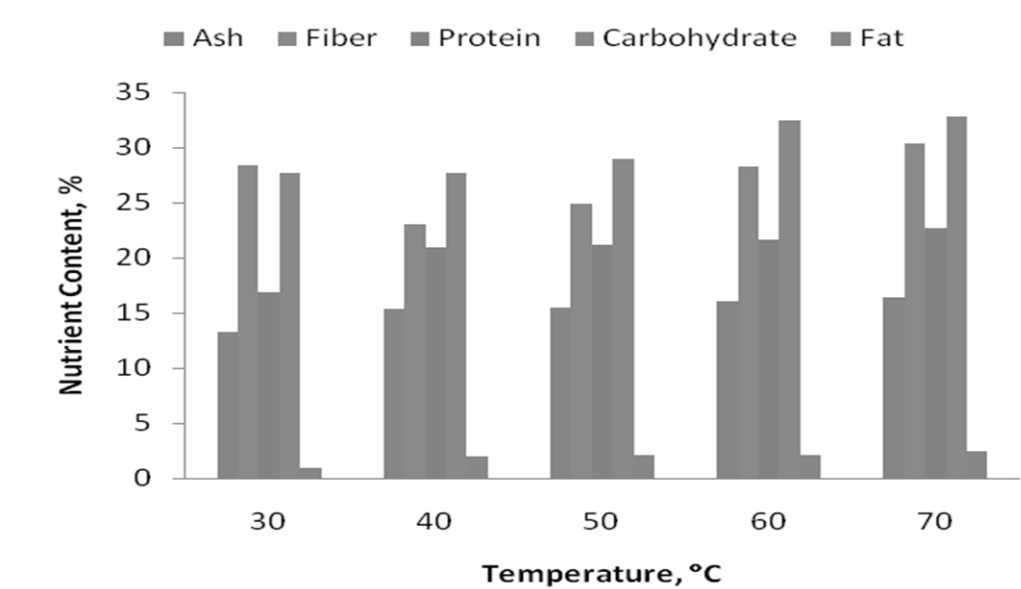


Figure 4: Nutrient contents versus drying temps. at equilibrium moisture contents

The relationship between the nutrients and the drying temperature as presented in Equations 9 to 13. Second order regression models described the relationship well. The R^2 values of above 0.7 means excellent relationship between the variables. Values of 0.5 and above are considered significant at 95% confidence interval (CI). As the drying temperature increased, the sample nutrient content generally increased. The removal of water ultimately leads the concentration of the other components. However, there was a slight decrease in the fibre and carbohydrate contents between 30 to 40 °C drying temperature, before a steady increase ensued. Increasing the temperature to this metabolism range and sustaining it at same for a substantial period of time may have encouraged more enzymatic degradation of these nutrients, leading to the ditch in these nutrient content. Some degradation of these nutrients via increased activities of the nutrient-degrading enzymes may have taken place before effective drying started. Even in nature, the mammalian body temperature range is 37 – 39 °C, while that for poultry 41 – 42 °C (Troxell *et al.*, 2015). Digestion of ingested food naturally takes place at these range of temperature. The attainment of the natural digestion temperature range may encourage the enzymatic degradation of the nutrients under artificial condition.

3.6 Phytochemicals and Nutritional – Temperature Models

The phytochemical and proximate quantities of the dried bush buck leaves were established by curve fitting and expressed mathematically as a function of the drying temperatures by second order polynomial models. The goodness of fit were also shown by the respective R^2 values. The close-to-1.0 values meant very good relationships between the variables. R^2 values of 0.5 and above are considered significant at 95 % confidence interval (CI). The results of the regression models are shown in Equations 6 to 16. Their coefficients of determination were also found to show strong relationships.

Terpenoids %	$= 0.003T^2 + 0.242T + 1.65;$	$(R^2 = 0.923)$	6	
Alkaloids %	$= 0.009T^2 + 0.073T + 3.914;$	$(R^2 = 0.987)$		7
Flavonoids %	$= 0.001T^2 + 0.092T + 3.508;$	$(R^2 = 0.943)$		8
Saponnins %	$= 0.057T^2 - 0.188T + 0.952;$	$(R^2 = 0.982)$		9
Tannins %	$= 0.027T^2 + 0.055T + 0.418;$	$(R^2 = 0.992)$		10
Moisture %wb	$= 0.006T^2 - 0.792T + 30.68;$	$(R^2 = 0.941)$		11

Ash. %	$= -0.217T^2 + 1.992T + 11.69;$	$(R^2 = 0.921)$	12
Fiber. %	$= 1.155T^2 - 6.006T + 32.27;$	$(R^2 = 0.789)$	13
Protien. %	$= -0.419T^2 + 3.762T + 13.97;$	$(R^2 = 0.895)$	14
Fat. %	$= -0.097T^2 + 0.892T + 0.288;$	$(R^2 = 0.869)$	15
Carbohydrate. %	$= 0.217T^2 + 0.207T + 26.91;$	$(R^2 = 0.900)$	16

In Equations 6 to 16, T is the oven temperature at which the *Utazi* leaves were dried.

Results of the data analysis show that there are strong relationships between the test variables (proximate and phytochemicals) and the process (drying temperatures) variables in the range of 30 °C to 70 °C. This is supported by the values of the coefficient of determination (R^2) which ranges from 0.789 for fibre to 0.992 for tannin. Time taken to reduce the mc of the bush buck leaves to an equilibrium mc also varied with the drying temperature and decreased with increasing drying temperature. The same trend was observed for the elapsed drying period up to the end of the falling rate period.

3.4 Effects of Drying Methods on Phytochemical and Nutrient Contents

Room Temperature (RTD) yielded the highest value of alkaloid (6.90%) followed by Convective Oven drying (OD) (4.00%) and Open Sun Drying (OSD) (3.25%). RTD yielded the highest value of flavonoid (6.80%) followed by OSD (3.75%) and OD (3.60%). OSD yielded the highest value of saponin (1.45%) followed by OD (0.80) and RTD (0.80%). OSD yielded the highest value of tannin (0.64%) followed by OD (0.48%) and RTD (0.29%). OSD yielded the highest value of terpenoids (2.45%) followed by RTD (4.00%) and OD (1.90%). RTD yielded the highest value of ash (13.25%) followed by RTD (13.07%) and OSD (12.22%). RTD yielded the highest value of fat (1.10%) followed by OD (0.95%) and OSD (0.68%). OD yielded the highest value of fibre (28.32%) followed by OSD (7.23%) and RTD (5.08%). RTD yielded the highest value of protein (17.07%) followed by OD (16.83%) and OSD (16.64%). RTD yielded the highest value of carbohydrate (58.38%) followed by OSD (54.87%) and OD (27.70%).

For the temperature range of 30 °C to 70 °C, the values of Alkaloid range from 4.0 to 4.5 %, from 3.60 to 3.92 % for flavonoids, from 0.80 to 1.46 % for saponins, from 0.48% to 1.39% for tannins and from 1.90 to 2.72% for terpenoids. In the same range of temperature (30 °C to 70 °C), the ash content ranged from 13.25 to 16.35%, fat content from 0.95 to 3.94%, fibre from 28.32 to 30.33%, protein from 16.83 to 22.70% and carbohydrate from 27.70 to 32.84%.

4. Conclusion

This paper reports the results of the investigation of the effects of drying temperatures on the proximate and phytochemical components of *Gongronema latifolium* (*Utazi*) leaves. The equilibrium moisture contents and drying times were in decreasing order of the drying temperatures, and varied from 12.95% for 30 °C to 5.03% for 70 °C drying temperatures. Increased nutritional and phytochemical contents correlated with higher drying temperatures. The study showed that drying temperature has influence on the dry matter content and nutritional contents of the dried product. The results also showed that drying methods affect the proximate and phytochemical contents of the dried leaves. Highest values of saponins, tannins and terpenoids were obtained from sun drying while alkaloids, flavonoids, carbohydrate, protein and fat were highest from room temperature drying and higher fibre values from oven drying in the dried leaves. The intended use of the dried leaves should therefore be considered in choosing the drying methods and conditions.

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