

INFLUENCE OF SLICE THICKNESS AND DRYING TEMPERATURE ON THE PROXIMATE COMPOSITION OKRA: IMPLICATIONS FOR NUTRITIONAL QUALITY AND DRYING PROCESS OPTIMIZATION

Muhammad Mujahid Muhammad^{1,*}, Abba Yahaya², Mohammed Abdulsalam³, Al-Amin Danladi Bello², Daniel Onwude⁴, Ibrahim Babangida Dalha³, Muhammad Bashir Abdulrazaq⁵, Badruddeen Saulawa Sani², Abdullahi Argungu Sule²

¹Department of Water Resource and Environmental Engineering, Ahmadu Bello University, Zaria - Nigeria

²Department of Water Resources and Environmental Engineering, Ahmadu Bello University, Zaria - Nigeria

³Department of Agricultural and Bioresources Engineering, Ahmadu Bello University, Zaria - Nigeria

⁴Swiss Federal Laboratory of Material Science and Technology, Empa, Switzerland

⁵Department of Computer Engineering, Ahmadu Bello University, Zaria - Nigeria

Email: mujahidmuhammad8@gmail.com*, abbayahaya85@yahoo.com, mabdulsalam@abu.edu.ng, adbello@abu.edu.ng, daniel.onwude@empa.ch, irobabangida13@gmail.com, mbabdulrazaq@abu.edu.ng, basaule@hotmail.com, abdummu1@gmail.com

***Corresponding author:** Muhammad Mujahid Muhammad

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ABSTRACT

Okra (*Abelmoschus esculentus* L. Moench) is a nutrient-dense vegetable, yet the losses remains significant due to high moisture content and poor postharvest handling.. A sustainable drying technique remains the most practical preserving method. A number research works have been report on the drying technique but multiple treatment condition often deteriorate the nutritional composition, particularly the slice thickness in relation to the drying temperature. This study evaluated the effect of slice thickness and drying temperature on the proximate composition of okra. Okra samples of 0.5, 1.0, 1.5 and 2.0 cm thicknesses were subjected to processing temperatures of 30, 50, 60 and 70°C, with three replicates for each treatment combination represented by samples A, B and C. Moisture, ash, lipid, protein, fibre and carbohydrate contents were determined and expressed as percentages. Across all 45 observations, mean moisture, ash, lipid, protein, fibre and carbohydrate contents were 12.51, 8.91, 4.82, 16.70, 7.61 and 57.05%, respectively. The highest mean protein content (20.12±0.09%) occurred at 1.5 cm thickness and 60°C, while the highest mean fibre content (8.75%) was also recorded at this treatment. The maximum mean carbohydrate content (62.62±0.35%) occurred at 0.5 cm and 50°C, whereas the highest mean lipid content (6.83%) occurred at 2.0 cm and 70°C. The results establish substantial variation in proximate composition with processing temperature and sample thickness, indicating an interaction between the two factors. A thickness of 1.5 cm combined with 60°C produced a particularly favorable protein- and fibre-rich profile. The findings provide a useful guidance for selecting processing conditions for nutritionally desirable dried okra products.

Keywords: okra; drying temperature; slice thickness; proximate composition

1. INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is a widely consumed vegetable valued for its protein, carbohydrate, dietary fibre, minerals, vitamins and bioactive compounds. Recent reviews have highlighted its phytochemical importance, emphasizing the need for efficient handling (Abdel-Razek et al., 2023). Also, fresh okra's high moisture content and postharvest physiological activity make it highly perishable, so drying is widely used to extend availability and ease storage and transportation. However, drying can alter the apparent concentrations and retention of nutritional components, with recent studies reporting differences in moisture, ash, fat, protein, fibre and carbohydrate contents depending on cultivar, pretreatment and drying technique (Mohammed et al., 2024; Ibeogu et al., 2024; Ogundele & Terzungwe, 2024).

Drying temperature affects moisture migration, drying rate, chemical reactions and nutrient retention; Afolabi et al. (2022) showed that temperature and time significantly influenced hot-air-dried okra quality and used statistical optimization to identify favourable process conditions. Sample thickness is equally important, as it affects surface area and the distance moisture must migrate: Pendre et al. (2012) demonstrated that slice size and drying temperature significantly influenced protein, ascorbic acid and fibre retention, with optimal retention at 2 cm/60°C, while El-Mesery et al. (2023, 2024) showed moisture diffusivity and drying kinetics were jointly governed by temperature and thickness, with drying duration increasing with slice thickness. Obasi et al. (2025) found moderate temperatures (50°C) better preserved proximate and mineral composition than higher-temperature drying, and Reid-Fitten et al. (2026) showed that thermal pre-treatment combined with drying method significantly influenced phytonutrient, vitamin and antioxidant retention. Similarly, Rababah et al. (2023) and Kolawole et al. (2024) and Maigari et al. (2026) reported that drying and storage conditions affect the physicochemical, nutritional and antioxidant quality of dried okra, reinforcing the need for optimised drying regimes.

Thus, this study assessed how sample thickness and drying temperature influence okra's proximate composition, aiming to identify treatment combinations yielding desirable nutritional characteristics.

2. METHODOLOGY

This section describes the sample collection, research design, materials, experimental procedures, data collection methods, and analytical or computational tools used.

2.1 Sample Collection and Preparation

Fresh, matured, disease-free okra pods were procured locally and transported in perforated crates to the environmental laboratory of the Department of Water Resources and Environmental Engineering, Ahmadu Bello University, minimising mechanical damage. Pods were then washed under running potable water to remove dirt and surface contaminants, and drained before further processing.

2.2 Experimental Design

The washed pods were sliced transversely into four thickness levels (0.5, 1.0, 1.5 and 2.0 cm) using a slicer and thickness guide/vernier caliper for dimensional accuracy, then dried at four temperature levels (30, 50, 60 and 70°C). The experiment followed a factorial design (thickness × temperature) with three replicates, yielding 16 treatment combinations and 48 expected observations. Three (3) contaminated samples were excluded as unsuitable, resulting in 45 observations for the final analysis.

2.3 Drying Procedure

Sliced samples were spread in a single layer on perforated trays and dried in a thermostatically controlled hot-air solar dryer at the respective treatment temperature (30, 50, 60 or 70°C) to constant weight, then cooled to room temperature, milled, and sieved through a 0.5 mm mesh. The resulting flour was packaged in airtight, labelled containers and stored at ambient temperature away from light pending proximate analysis.

2.4 Proximate Analysis

Proximate composition of the dried okra flour samples was determined in triplicate using standard AOAC (2023) methods. Specifically, moisture and ash were determined gravimetrically, via oven-drying at 105 °C and muffle-furnace incineration at 550 °C, respectively, while crude lipid was extracted using the Soxhlet method with n-hexane/petroleum ether. In addition, crude protein was determined by the micro-Kjeldahl method (nitrogen × 6.25), and crude fibre by sequential acid-alkali digestion and ashing. Finally, carbohydrate (CHO) was estimated by difference, as $\text{CHO (\%)} = 100 -$

(% Moisture + % Ash + % Lipid + % Protein), consistent with common practice in food-science studies where fibre is analysed separately.

2.5 Data Analysis

Data were expressed as mean $\pm$ standard deviation (SD) ($n = 3$) and analysed using descriptive statistics and one-way analysis of variance (ANOVA) in IBM SPSS Statistics. ANOVA was used to determine the effects of slice thickness and drying temperature on each proximate composition parameter, with statistical significance set at $p < 0.05$. All statistical computations were performed using standard procedures in SPSS.

3. RESULTS AND DISCUSSION

3.1 Overall Proximate Composition

Table 1 shows carbohydrate as the largest proximate fraction, followed by protein, ash, fibre and lipid, with mean moisture (12.51%) reflecting substantial water loss within the acceptable ($<13\%$) range for shelf-stable dried vegetables, comparable to Obasi et al. (2025). This apparent concentration of solid constituents through water removal is consistent with recent reports on dried okra (Maigari et al., 2026). The mean protein content (16.70%) suggests dried okra can meaningfully contribute to dietary protein in composite flour and snack formulation, with recent studies reporting values approaching 20% depending on drying method and pre-treatment (Ibeogu et al., 2024). The high carbohydrate proportion likewise reflects typical dried-plant composition, best interpreted as a relative concentration effect rather than carbohydrate synthesis during drying. Also, Table 2 presents the complete mean $\pm$ SD values for all six proximate parameters across the sixteen slice thickness-drying temperature combinations investigated in this study, and is referenced throughout the subsections that follow.

Table 1: Mean proximate composition of dried okra

Parameter	Mean $\pm$ SD (%)	Minimum (%)	Maximum (%)
Moisture	12.51 $\pm$ 0.63	11.05	13.90
Ash	8.91 $\pm$ 1.54	7.06	11.56
Lipid	4.82 $\pm$ 0.93	3.56	6.83
Protein	16.70 $\pm$ 2.31	12.25	20.12
Fibre	7.61 $\pm$ 0.62	6.40	8.75
Carbohydrate (CHO)	57.05 $\pm$ 3.12	51.55	62.62

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Table 2: Proximate composition of dried okra by slice thickness and drying temperature

Thickness (cm)	Temp. (°C)	Moisture (%)	Ash (%)	Lipid (%)	Protein (%)	Fibre (%)	CHO (%)
0.5	30	11.98 ± 0.86	10.18 ± 0.03	4.13 ± 0.07	15.97 ± 0.19	8.33 ± 0.03	57.74 ± 0.97
0.5	50	12.25 ± 0.28	8.82 ± 0.03	3.94 ± 0.01	12.35 ± 0.14	8.18 ± 0.03	62.62 ± 0.35
0.5	60	13.60 ± 0.36	9.94 ± 0.04	5.16 ± 0.04	17.41 ± 0.02	7.88 ± 0.02	53.89 ± 0.40
0.5	70	12.75 ± 0.10	9.82 ± 0.09	5.34 ± 0.11	15.32 ± 0.08	8.07 ± 0.08	56.77 ± 0.13
1.0	30	12.35 ± 0.48	9.60 ± 0.02	4.97 ± 0.12	17.80 ± 0.06	7.77 ± 0.03	55.28 ± 0.42
1.0	50	11.49 ± 0.30	8.35 ± 0.05	4.41 ± 0.47	14.84 ± 0.14	7.43 ± 0.03	60.90 ± 0.65
1.0	60	12.72 ± 0.65	8.20 ± 0.05	4.48 ± 0.03	18.87 ± 0.12	7.23 ± 0.03	55.73 ± 0.66
1.0	70	12.67 ± 0.08	7.51 ± 0.10	5.02 ± 0.03	19.40 ± 0.14	7.33 ± 0.10	55.39 ± 0.24
1.5	30	12.33 ± 0.37	8.53 ± 0.18	3.56 ± 0.30	13.75 ± 0.03	7.45 ± 0.05	61.83 ± 0.17
1.5	50	13.60 ± 0.15	9.51 ± 0.14	3.51 ± 0.17	13.82 ± 0.03	7.19 ± 0.04	59.56 ± 0.11
1.5	60	12.02 ± 0.16	11.41 ± 0.19	4.67 ± 0.14	20.12 ± 0.09	8.70 ± 0.05	51.77 ± 0.22
2.0	30	12.02 ± 0.03	10.69 ± 0.22	4.54 ± 0.09	19.39 ± 0.04	8.13 ± 0.03	53.36 ± 0.29
2.0	50	12.46 ± 0.01	5.49 ± 0.24	5.26 ± 0.20	18.38 ± 0.11	6.43 ± 0.03	58.41 ± 0.24
2.0	60	12.60 ± 0.09	7.06 ± 2.08	6.45 ± 0.05	17.17 ± 0.02	6.52 ± 0.03	56.72 ± 2.11
2.0	70	12.87 ± 0.15	8.55 ± 0.05	6.83 ± 0.06	15.91 ± 0.01	7.55 ± 0.05	55.84 ± 0.23

3.2 Effects of Slice Thickness and Drying Temperature on Proximate Parameters

Moisture content ranged from 11.05% (0.5 cm, 30°C) to 13.90% (0.5 cm, 60°C) (Tables 1 and 2). Using the data in Table2, One-way ANOVA indicated that neither slice thickness ($F = 0.74$, $p = 0.536$) nor drying temperature ($F = 2.38$, $p = 0.084$) significantly affected moisture ($p > 0.05$), though a weak upward trend at higher temperatures likely reflects case-hardening, rapid surface drying that traps residual internal moisture, consistent with El-Mesery et al. (2024), who found drying rate and moisture diffusivity jointly governed by temperature, airflow and thickness.

Ash content ranged from $5.49 \pm 0.24\%$ (2.0 cm, 50°C) to 11.56% (1.5 cm, 60°C), with both thickness ($F = 5.15$, $p = 0.004$) and temperature ($F = 3.02$, $p = 0.041$) showing significant effects. Highest retention occurred at 1.5 cm/60°C, while lower, more variable values in the 2.0 cm/50–60°C

treatments may reflect uneven heat penetration and localised mineral loss, agreeing with Obasi et al. (2025) on temperature's influence on ash composition.

Lipid content rose significantly with both thickness ($F = 13.53$, $p < 0.001$) and temperature ($F = 9.90$, $p < 0.001$), from $3.56 \pm 0.30\%$ (1.5 cm, 30°C) to 6.83% (2.0 cm, 70°C), likely due to a concentrating effect as moisture is removed.

Crude protein ranged from 12.25% (0.5 cm, 50°C) to $20.12 \pm 0.09\%$ (1.5 cm, 60°C), significantly affected by both thickness ($F = 4.24$, $p = 0.011$) and temperature ($F = 6.52$, $p = 0.001$). Peak retention at 1.5 cm/ 60°C mirrors Pendre et al. (2012), reflecting a favourable balance between drying rate and thermal intensity, while lower protein at 50°C may reflect prolonged enzymatic activity during slower drying.

Crude fibre varied from 6.40% (2.0 cm, 50°C) to 8.75% (1.5 cm, 60°C), significantly affected by thickness ($F = 7.68$, $p < 0.001$) but not temperature ($F = 2.12$, $p = 0.113$). Fibre declined beyond 1.5 cm thickness (Table 2), supporting 1.0–1.5 cm as optimal for fibre-dense product.

Carbohydrate (by difference) ranged from 51.55% (1.5 cm, 60°C) to $62.62 \pm 0.35\%$ (0.5 cm, 50°C), significantly affected by temperature ($F = 14.27$, $p < 0.001$) but not thickness ($F = 0.73$, $p = 0.538$). Its strong inverse correlation with protein ($r = -0.85$) reflects the by-difference calculation rather than independent carbohydrate behaviour.

Overall, thickness and temperature jointly, rather than independently, determined proximate quality: The 1.0 and 2.0 cm samples had the highest average protein concentration of 17.73% and peaked at 60°C (18.39%) before declining at 70°C , whereas 0.5 cm had the highest average fibre content of 8.12% . The 2.0 cm samples had the highest average lipid content of 5.77% and rose progressively with temperature; and carbohydrate peaked at 50°C (Afolabi et al., 2022). The 1.5 cm $\times$ 60°C treatment gave the best protein, fibre and ash retention, while peak carbohydrate and lipid occurred at 0.5 cm $\times$ 50°C and 2.0 cm $\times$ 70°C , respectively.

4. CONCLUSION

This study demonstrated that slice thickness and drying temperature interactively influences the proximate composition of dried okra significantly. Within the range of the slice thickness and drying temperature examined, it was noticed the moisture content does not significantly affected by either factor. Interestingly, both slice thickness and drying temperature significantly influenced the ash, lipid, protein and carbohydrate contents.. The treatment combination of 1.5 cm slice thickness dried at 60°C consistently produced dried okra with the highest protein, ash and fibre retention, while thinner slices (0.5 cm) dried at moderate temperature (50°C) favoured maximum carbohydrate retention with the lowest protein and ash concentration. These results confirm that slice thickness and drying temperature cannot be optimised independently; rather, the appropriate combination should be selected according to the intended nutritional or functional target of the final dried okra product.

Furthermore, a thickness of approximately 1.5 cm and 60°C should be investigated further as a potential optimum for protein- and fibre-rich dried okra.

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