Kwaghe International
Journal of Sciences and Technology

ISSN: 1595-7977

Index: Harvard, Boston, Sydney University, Dimensions, Lens, ResearchGet Scilit, Semantic, Google, Base etc

https://doi.org/10.58578/KIJST.v3i3.12572

Nutritional Composition and Socio-Economic Importance of the Shea Butter Caterpillar, *Cirina forda* (Westwood), as a Non-Wood Forest Product in Southern Taraba State, Nigeria

Bukar M. G.[1], Maza V. H.[2], Segunle K. A.[3],Oni P. I.[4]

[1,2,3]Federal University Dutsin-Ma, Katsina State, Nigeria

[4]Federal University Wukari, Taraba State, Nigeria

mvhikon1@gmail.com

Submitted:	Revised:	Accepted:	Published:
Sep 23, 2026	Oct 22, 2026	Nov 2, 2026	Nov 7, 2026

Abstract

Edible insects provide alternative nutrient sources and contribute to food security and rural livelihoods. This study assessed the nutritional composition and socioeconomic importance of the shea butter caterpillar, *Cirina forda* (Westwood), a seasonal non-wood forest product harvested from *Vitellaria paradoxa* trees in southern Taraba State, Nigeria. Fresh larvae were collected from selected trees across five local government areas, cleaned, and oven-dried at 60°C for 24 hours. Proximate composition was determined using AOAC (2012) methods, while minerals, vitamins, and antinutrients were analyzed spectrophotometrically. Statistical analyses employed t-tests and Duncan's multiple range test at $p \leq .05$. Socioeconomic data were collected through 200 questionnaires administered to collectors and traders. Drying significantly increased crude protein from 20.10% to 24.62% and reduced moisture from 10.74% to 6.44% ($p < .05$). Iron and zinc concentrations increased from 2.70 to 4.70 ppm and from 1.11 to 1.70 ppm, respectively, whereas sodium decreased from 3.63 to 3.16 ppm. Reported thiamine (vitamin B1) values declined from 97.8% to 10.9%, while retinol (vitamin A) was largely retained. Phytate and oxalate increased after drying. Among respondents, 56% were female, 39.5% were aged 18–25 years, and 48.5% belonged to households comprising 4–6 people. The socioeconomic findings indicated that *C. forda* contributed substantially to household livelihoods. Overall, the study identifies *C. forda* as a potential source of protein and minerals and an important rural livelihood resource. The processing-related changes in nutrients and

KIJST Journal is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License

antinutrients highlight the need for improved processing practices, alongside marketing interventions to support its socioeconomic value.

Keywords: *Cirina forda*; Entomophagy; Non-Wood Forest Products; Nutritional Composition; Rural Livelihoods

INTRODUCTION

Entomophagy, the human consumption of insects, is practiced in many cultures worldwide and nutritionally significant, contributing protein, fat, vitamins, and minerals to diets in many parts of the world, including Nigeria, Ghana, Cambodia, China, Mexico, and Thailand (Peshuk *et al.,* 2022; Chidozie-Ogwu, 2025). Edible insects are especially important to rural livelihoods, offering species with high-quality, digestible protein and favourable fatty- and amino-acid profiles comparable to conventional livestock and fish (Kosoe *et al.,* 2025; Sadaf *et al.,* 2026). Among edible insects, members of the order Lepidoptera are recognized for their high nutritional value, particularly their rich protein, lipid, vitamin, and mineral contents. One of the most important species is the shea butter caterpillar, *Cirina forda* is an edible caterpillar belonging to the family Saturniidae associated particularly with *Vitellaria paradoxa* (shea tree), an important host plant in West Africa for both food and income generation (Spitsyn *et al.,* 2021; Nemadodzi *et al.,* 2023). It is known locally by names including Tsutsa Kadaya (Hausa), Shishi Kwata (Jukun Wapan), and Igyo (Tiv). *Cirina forda* has a distinct seasonal life cycle in which eggs are laid predominantly from May to June, while the larvae occur mainly from June to August, with peak larval abundance and harvesting generally reported in July and August. Larvae are found in groups on shea butter trees (*Vitellaria paradoxa*) and are collected by local communities, involving women significantly in the collection, processing and marketing of the larvae (Nemadodzi *et al., 2023*; Oguche *et al.,* 2024).

Nigeria still has high level food and nutrition insecurity with a significant proportion of its population having limited access to adequate and nutritious food. The Cadre Harmonisé analysis in 2024 estimated 33.1 million Nigerians to be in severe food insecurity during the lean season of June-August 2025, highlighting persistent challenges in food access, informed by inadequate prices (FAO, 2024). Edible insects, including *Cirina forda*, represent a potentially accessible source of animal protein and micronutrients because the larvae are locally available and traditionally traded in affected communities in parts of Nigeria. Studies have demonstrated the high nutritional value of *C. forda,* including

substantial protein and mineral contents, while recent reviews identify edible insects as potential alternative protein sources that can contribute to food security and livelihoods in Nigeria (Adepoju and Daboh, 2020; Aigbedion-Atalor *et al.,* 2024). However, wider utilization of edible insects may be constrained by declining consumption in some communities, changing food preferences, limited scientific and commercial development, and inadequate documentation of their nutritional and socioeconomic potential (Adepoju and Daboh, 2020; Aigbedion-Atalor *et al.,* 2024).

Although previous studies have examined the nutritional characteristics and processing effects of *Cirina forda* in Nigeria, including Oguche *et al.* (2024) in Wukari Local Government Area, limited information exists on the comparative nutritional composition of fresh and traditionally dried *C. forda* in Southern Taraba State. Furthermore, limited integrated information is available on its socio-economic importance, collection, processing, marketing and value chain in the region (Nemadodzi *et al.*, 2023; Oguche *et al.*, 2024). Therefore, a location-specific assessment comparing the proximate, anti-nutritional, mineral and vitamin composition of fresh and dried *C. forda*, alongside its socio-economic significance to collectors, processors and traders, is needed.

As an edible forest resource, *C. forda* contributes to household food supplies and income generation through collection, processing and marketing. It is among the economically important edible caterpillars traded in West Africa, including Nigeria, where it supports rural livelihoods (Nemadodzi *et al.*, 2023). However, concerns about resource availability and sustainable management remain. Assessing its nutritional and socio-economic value in Southern Taraba is therefore important for understanding its contribution to household nutrition and livelihoods and informing sustainable utilization strategies. This study evaluated the nutritional composition and socio-economic importance of *C. forda* in Southern Taraba State, Nigeria.

Theoretical Framework

This study is guided by an integrated sustainable-livelihood and food-and-nutrition-security perspective, which conceptualizes *Cirina forda* as both a food resource and a livelihood asset. As a non-wood forest product, *C. forda* can contribute to household food supplies, income generation and livelihood diversification through harvesting, processing and marketing (Derebe and Alemu, 2023; Nemadodzi *et al.,* 2023). Its livelihood value is

influenced by resource availability, seasonal occurrence, harvesting practices and market opportunities.

Additionally, the food and nutrition security perspective identifies edible insects as a source of dietary protein, minerals and other nutrients. But processing can change their nutritional and anti-nutritional composition which consequently impacts the final product quality (Matiza Ruzengwe *et al*., 2022). This is especially applicable to *C. forda* because the processing studies carried out in Taraba state has shown a difference in the proximate and anti-nutrient composition following various processing method employed (Oguche *et al.,* 2024). With this, the framework connects resource availability, harvesting, processing, nutritional composition and socio-economic utilization. It serves as basis for the nutritional profile of fresh and dried *C. forda* as well as its socio-economic significance in Southern Taraba State.

MATERIALS AND METHODS

Study Area

This study was carried out in the Southern Senatorial District of Taraba State, which consists of Ibi, Wukari, Donga, Takum and Ussa Local Government Areas (LGAs) of the Northeast of Nigeria. The district extends approximately from 6°30′56″ to 8°46′26″N and 9°06′25″ to 10°45′39″E, covering an estimated area of 14,195.8 km² (Asa and Zemba, 2024). The area experiences distinct wet and dry seasons, with rainfall generally beginning between March and May and terminating between October and December, depending on location. Annual rainfall varies considerably across the district, with lower amounts generally recorded in Ibi, Wukari and Donga and higher amounts in Takum and Ussa (Asa *et al*., 2024). Reported mean temperatures across Southern Taraba vary spatially, with values approximately within the range of 27.5-32°C, while the vegetation comprises derived savanna in Ibi, Wukari and Donga and tropical rainforest–savanna vegetation in Takum and Ussa (Asa and Zemba, 2024). These climatic and vegetation conditions support the growth of Vitellaria paradoxa, the principal host tree associated with the seasonal occurrence of *Cirina forda.*

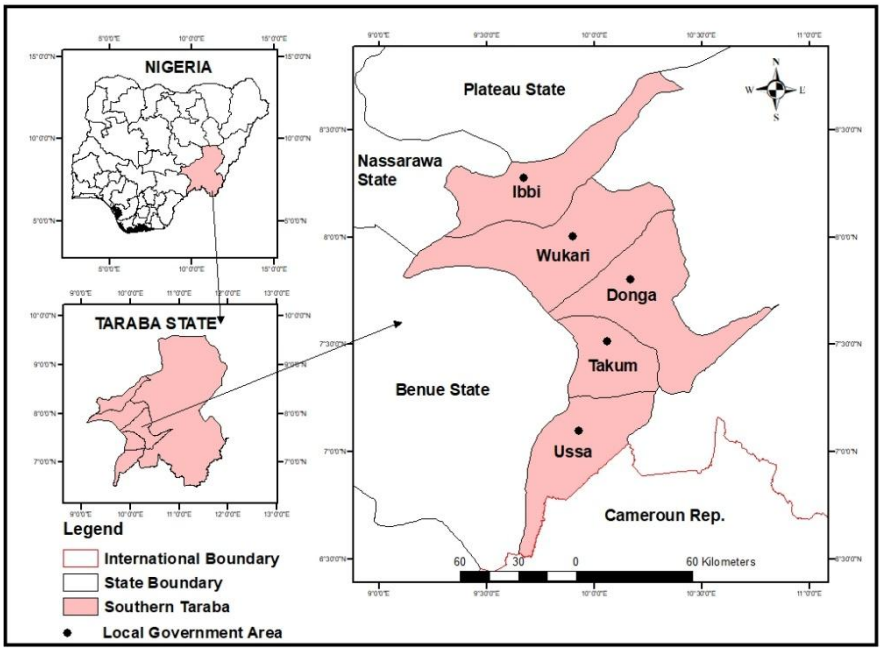


Figure 1: Map showing the study area and sampled Local Government Areas in Southern Taraba State, Nigeria

Sampling Technique

A multistage sampling technique was adopted. The five LGAs in Southern Taraba; Ussa, Donga, Ibi, Takum and Wukari were included in the study. Within each LGA, communities with a history of *Cirina forda* harvesting were purposively selected based on field reconnaissance and consultation with community leaders and relevant agricultural authorities. *Vitellaria paradoxa* trees with active *C. forda* infestation were identified, tagged and geo-referenced using a handheld GPS, after which sampling trees were selected by simple random sampling. For the socio-economic component, individuals involved in the collection, processing, marketing or consumption of *C. forda* were purposively selected with assistance from community leaders. Forty respondents were selected from each LGA, giving a total of 200 respondents. *C. forda* samples were collected from infested V. paradoxa trees in the selected communities across the five LGAs

Sample Collection and Preparation

Fresh *Cirina forda* larvae were hand-harvested during the rainy season from randomly selected Vitellaria paradoxa trees across the five LGAs of Southern Taraba; Ussa, Donga, Ibi, Takum and Wukari. The samples were transported to the Department of Forestry and Wildlife Management, Federal University Wukari, for identification and

processing. The larvae were divided into two batches: one was analyzed in the fresh state, while the other was oven-dried at 60°C for 24 hours, milled into flour, and subjected to laboratory analyses

Chemical Analyses

Proximate composition (moisture, crude protein, crude fat, crude fibre, ash, and carbohydrate by difference) was determined in duplicate using standard AOAC (2012) methods. Mineral content (iron, zinc, magnesium, potassium, calcium, and sodium) was determined by atomic absorption spectrophotometry following AOAC Official Method 985.35 (AOAC International, 2012). Vitamins A, B1 (thiamine), B2 (riboflavin), B3 (niacin), B6 (pyridoxine), C (ascorbic acid), and E (α-tocopherol) were quantified using standard spectrophotometric assays, and anti-nutrients (phytate, saponin, tannin, alkaloid, and oxalate) were determined using established titrimetric and spectrophotometric procedures.

Experimental Design and Statistical Analysis

The laboratory experiment was conducted using a Completely Randomized Design (CRD) with treatment factor as the form of samples (fresh and dried). The statistical analysis of data was performed by independent-samples t-test and Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$ using SPSS version 26 (SPSS Inc., USA) and compared between fresh and dried samples. Descriptive statistics (frequency counts and percentages) were used to analyse the socio-economic data from the 20 questionnaires completed.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Respondents

The demographic profile of the 200 respondents provides a valuable context for understanding the potential for entomophagy within the study population as presented in Table 1. The slight female majority (56.0%) aligns with the well-documented role of women as primary actors in the harvesting, processing, and marketing of edible insects in Africa (Kusia *et al.,* 2023; Nemadodzi *et al*., 2023). This gendered participation is integral to both household food security and income generation, suggesting that nutritional interventions involving insects would directly engage a key demographic. The predominance of younger respondents (39.5% aged 18-25) is a critical finding for the future of entomophagy, as studies indicate that younger populations are generally more

receptive to novel foods (Li *et al.,* 2023). However, this age group also represents a demographic where traditional insect consumption practices are declining in some regions, underscoring the need for proactive promotion and education (Hlongwane *et al.,* 2020; Kusia *et al.,* 2023). The typical household size of 4-6 persons (48.5%) reinforces the relevance of insects as a sustainable protein source to address food insecurity, a challenge exacerbated by increasing global population and demand (Hlongwane *et al.,* 2020; Lu *et al*., 2024). Furthermore, the high proportion of respondents with secondary education (32.5%) offers a strategic advantage, as increased awareness and knowledge of the nutritional and environmental benefits of insects are positively correlated with consumer acceptance and willingness to adopt these foods (Gachihi *et al*., 2023; Li *et al*., 2023).

Table 1: Socio-demographic characteristics of respondents involved in Cirina forda utilization in Southern Taraba State, Nigeria

Characteristic	Category	Frequency (n = 200)	Percentage (%)
Gender	Male	88	44.0
	Female	112	56.0
Age (years)	18–25	79	39.5
	26–35	53	26.5
	36–45	39	19.5
	46–55	29	14.5
Marital status	Married	43	21.5
	Single	89	44.5
	Divorced	40	20.0
	Widowed	28	14.0
Household size	1–3	31	15.5
	4–6	97	48.5
	7–9	53	26.5
	10 and above	19	9.5
Education	No formal education	38	19.0
	Primary	53	26.5
	Secondary	65	32.5
	Tertiary	44	22.0

(Field survey, 2024).

There was a high awareness of *Cirina forda* across all LGAs as revealed in Figure 2, similar to previous result in Nigeria with 99.8% awareness (Adepoju and Daboh, 2020). This is due to its great availability of its host plant (*Vitellaria paradoxa*) and its continuity of knowledge from one generation to the next, with 93.2% of consumers having started consuming at childhood (Adepoju and Daboh, 2020). Species is socio-economically

significant in rural livelihoods as a source of income and as a household food supplement as presented in Figure 3 as documented by Nemadodzi *et al.*, (2023). This is in line with the global literature on edible saturniids as vital NTFP to food security and income generation in sub-Saharan Africa (Kusia *et al.*, 2023).

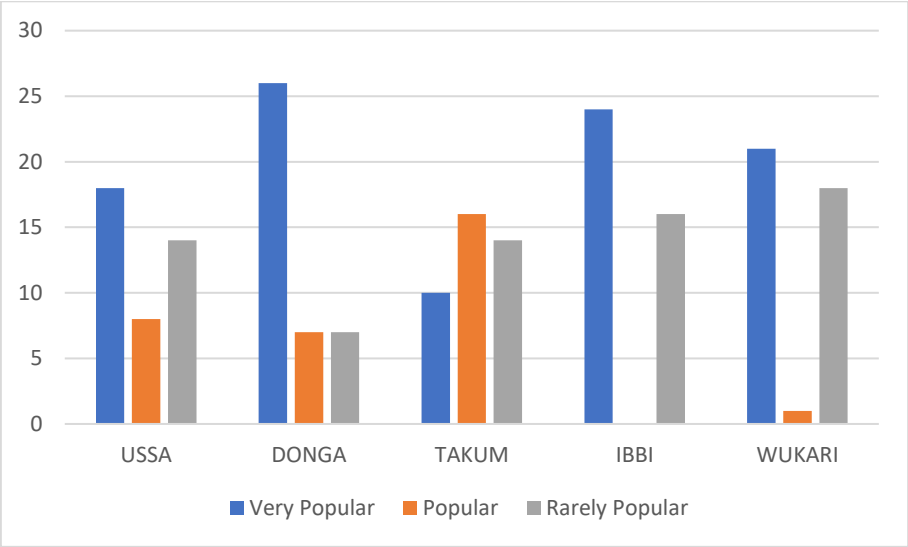


Figure 2: Respondents' awareness of Cirina forda across the five Local Government Areas of Southern Taraba State

Figure 4 indicates that *C. forda* is a major source of supplementary income in the five LGAs with highest proportions being obtained in Ussa (30%), Wukari (25%), Ibbi (23%), Donga (20%) and Takum (18%). This suggests that households in general engage in multiple livelihoods and income from *C. forda* supplements the other livelihoods. The results support those of Nemadodzi *et al.,* (2023), finding edible caterpillars (*C. forda*) as important sources of livelihood support and income for rural farmers in Africa. Likewise, Muvatsi *et al.* (2021) revealed that *C. forda* was significant forest resource that provides nutrition and income to the rural communities. Differences between LGAs may be due to differences in caterpillar availability, availability of host trees, harvesting practices and local market opportunities.

The income obtained from *C. forda* trading was not the same in the five LGAs as shown in figure 5. Traders earning ₦500-1,000 were most prevalent in Ussa, those earning ₦1,100-2,000 in Ibbi and Wukari and those earning over ₦ 4,100 most prevalent in Donga. This variation could be due to the availability of caterpillars, volume of trading, demand in the market, and market access. *C. forda* is noted as a marketable edible insect in Nigeria with the availability of the insect during the season (Adepoju and Daboh, 2020). Agbidye *et al.*

(2009) also recorded significant amount of *C. forda* being sold by marketers in Benue State, which also underlines its economic significance. Equivalent economic value has been reported at other locations in Africa: USD 3.5 per kg of dried *C. butyrospermi* and USD 6 per 750 g dried *G. oyemensis*, with a profit margin up to 69% for the traders, according to Nemadodzi *et al.* (2023). The results of this investigation corroborate the present observation that the *C. forda* trading presents a valuable alternative to the seasonal income but varies depending on market conditions and location.

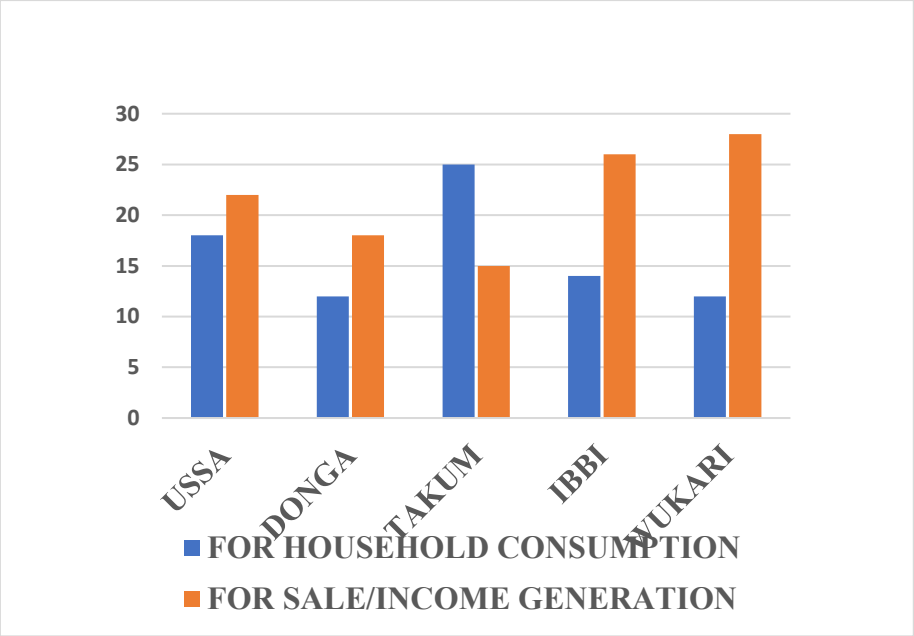


Figure 3. Primary purpose of Cirina forda harvesting across the five Local Government Areas of Southern Taraba State

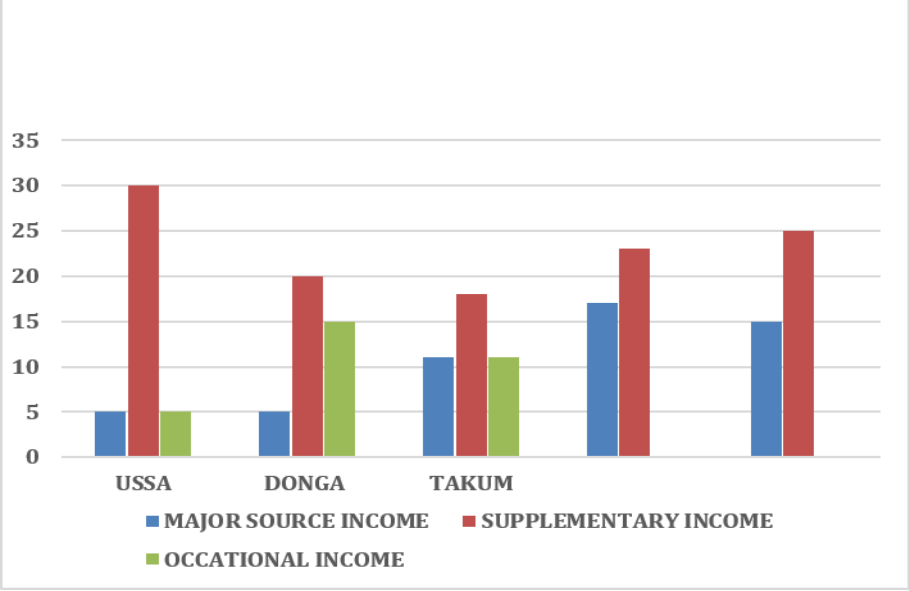


Figure 4: Utilization patterns of Cirina forda across the five Local Government Areas of Southern Taraba State

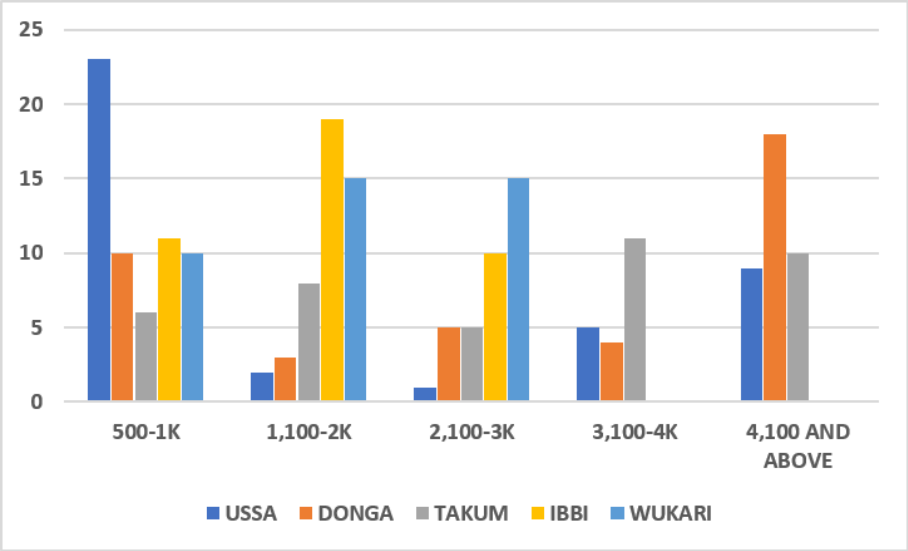


Figure 5. Reported profitability of Cirina forda trading across the five Local Government Areas of Southern Taraba State

Proximate Composition of Fresh and Dried *Cirina forda*

Table 2 shows that oven-drying significantly ($p < 0.05$) altered the proximate composition of *Cirina forda* larvae. Moisture decreased from 10.74 ± 0.03% to 6.44 ± 0.03%, indicating effective moisture removal and improved storage potential (Mutungi *et al.,* 2019). Consequently, the measured crude protein concentration increased from 20.10% in fresh larvae to 24.62% after drying, likely reflecting concentration associated with moisture removal, consistent with previous reports for *C. forda* (Hlongwane *et al.,* 2020; Kusia *et al*., 2023; Nemadodzi *et al*., 2023). However, the present protein values were lower than the 52.6-56.26% reported by Oguche *et al.* (2024) and Adepoju and Daboh (2013), suggesting that larval diet, geographic origin and processing conditions may influence nutrient composition. The reduction in crude fat may reflect lipid oxidation and/or differences associated with processing, whereas the slight reduction in ash may reflect analytical variation, redistribution or loss of soluble mineral components (Rumpold and Schlüter, 2013). Conversely, crude fibre showed a small but statistically significant increase from 9.06 ± 0.03% to 9.10 ± 0.03%, while carbohydrate increased from 31.59 ± 0.01% to 33.59 ± 0.01%, mainly reflecting concentration effects associated with moisture removal rather than new nutrient synthesis (Oguche *et al.,* 2024). Similar processing-related changes have been reported in *C. forda*, including increased protein and reduced fat following processing or defatting (Edah and Owolabi, 2024). Oven-drying substantially reduced moisture while retaining and concentrating protein, with only modest changes in fat, ash, fibre and carbohydrate content.

Table 2: Table 2. Proximate composition (%) of fresh and oven-dried Cirina forda larvae

Sample	Moisture	Crude protein	Crude fat	Crude fibre	Ash	Carbohydrate
Fresh C. forda	$10.74^{a} \pm 0.03$	$20.10^{b} \pm 0.14$	$21.61^{a} \pm 0.00$	$9.06^{b} \pm 0.03$	$6.90^{a} \pm 0.14$	$31.59^{a} \pm 0.01$
Dried C. forda	$6.44^{b} \pm 0.03$	$24.62^{a} \pm 0.03$	$19.85^{b} \pm 1.01$	$9.10^{a} \pm 0.03$	$6.40^{b} \pm 0.28$	$33.59^{b} \pm 0.01$

Values are presented as mean ± SD. Means within a column bearing different superscript letters differ significantly ($p < 0.05$).

Vitamin Composition

Table 3 shows that oven-drying significantly ($p \leq 0.05$) reduced all vitamins analyzed in *Cirina forda* larvae. Vitamin A decreased from 2.20 ± 0.14 to 2.00 ± 0.14 µg, vitamin E from 3.20 ± 0.30 to 1.85 ± 0.03 µg, vitamin B1 from 97.80 ± 0.30 to 10.90 ± 0.14%, vitamin B2 from 0.43 ± 0.03 to 0.32 ± 0.03 mg/100 g, vitamin B3 from 92.60 ± 0.30 to 89.10 ± 0.03%, and vitamin B6 from 65.40 ± 0.30 to 60.10 ± 0.14%. The significant decrease in vitamin B1 was probably due to the high thermal degradation of thiamine and the decrease in vitamin A and E could be attributed to thermal degradation-induced oxidation (Rumpold and Schlüter, 2013; Kusia *et al.*, 2023). The same vitamin content has been reported in *C. forda* with variations depending on sample conditions and analytical parameters (Daboh, 2020; Nemadodzi *et al.,* 2023). The results from these findings show that although oven drying improved the preservation, it should be possible to enhance vitamin retention in the dried product, which is possible by optimizing the drying temperature and duration, in order to minimize the nutrient losses.

Table 3: Vitamin composition of fresh and oven-dried Cirina forda larvae

Sample	Vit. A (µg)	Vit. B1 (%)	Vit. B2 (mg/100g)	Vit. B3 (%)	Vit. B6 (%)	Vit. E (µg)
Fresh C. forda	2.20 ± 0.14^{a}	97.80 ± 0.30^{a}	0.43 ± 0.03^{a}	92.60 ± 0.30^{a}	65.40 ± 0.30^{a}	3.20 ± 0.30^{a}
Dried C. forda	2.00 ± 0.14^{b}	10.90 ± 0.14^{b}	0.32 ± 0.03^{b}	89.10 ± 0.03^{b}	60.10 ± 0.14^{b}	1.85 ± 0.03^{b}

Values are means ± SD; means within a column bearing different superscripts differ significantly ($p \leq 0.05$, DMRT).

Mineral Composition

The concentrations of most of the minerals were significantly ($p \leq 0.05$) elevated by oven drying in *Cirina forda* larvae as indicated in Table 4. Iron increased from 2.70 ± 0.30 to 4.70 ± 0.30 ppm, zinc from 1.11 ± 0.14 to 1.70 ± 0.30 ppm, magnesium from 0.05 ± 0.00 to 0.09 ± 0.00 ppm, potassium from 7.59 ± 0.27 to 9.29 ± 0.03 ppm, and calcium from 0.54

± 0.03 to 0.70 ± 0.50 ppm, while sodium decreased from 3.63 ± 0.03 to 3.16 ± 0.03 ppm. These increases may be attributed to moisture loss, and thereby a concentration of minerals left behind, similar to Hlongwane *et al.* (2020) and Ombeni *et al.* (2024). The decrease in sodium indicates that the mineral reactions to drying may differ for different elements.

The mineral concentrations that were obtained were lower than those reported for *C. forda* and other saturniid caterpillars including the higher iron levels reported by Atowa *et al.* (2021) and magnesium, calcium levels reported by Ombeni *et al.* (2024) which may be attributed to geographic origin, soil type, host plant (*Vitellaria paradoxa*), developmental stage, and processing conditions as reported by Kusia *et al.* (2023). The higher levels of iron and zinc, however, are nutritionally significant since they are required to prevent micronutrient deficiencies. Oven drying significantly affected the mineral profile of *C. forda* with the nutrients becoming concentrated after moisture removal, but without significant loss of minerals of nutritional importance.

Table 4: Mineral composition of fresh and oven-dried Cirina forda larvae

Sample	Iron (ppm)	Zinc (ppm)	Magnesium (ppm)	Potassium (ppm)	Calcium (ppm)	Sodium (ppm)
Fresh C. forda	2.70 ± 0.30^{b}	1.11 ± 0.14^{b}	0.05 ± 0.00^{b}	7.59 ± 0.27^{b}	0.54 ± 0.03^{b}	3.63 ± 0.03^{a}
Dried C. forda	4.70 ± 0.30^{a}	1.70 ± 0.30^{a}	0.09 ± 0.00^{a}	9.29 ± 0.03^{a}	0.70 ± 0.5^{a}	3.16 ± 0.03^{b}

Values are means ± SD; means within a column bearing different superscripts differ significantly ($p \leq 0.05$, DMRT).

Anti-Nutrient Composition

Oven-drying significantly ($p \leq 0.05$) increased all anti-nutritional factors analyzed in *Cirina forda* larvae, with phytate increasing from 4.22% to 6.74%, saponin from 1.99% to 4.20%, alkaloid from 3.27% to 6.33%, oxalate from 8.21% to 11.53%, and tannin from 1.37 to 1.44 mg/100 g. These increases likely reflect apparent increases in concentration of the compounds following moisture loss rather than their formation during drying. Similar evidence indicates that processing conditions influence anti-nutrient retention in *C. forda*; Oguche et al. (2024) reported higher phytate in fried (4.6 ± 0.13) than boiled larvae, while Adepoju and Daboh (2020) reported negligible or undetectable levels of several anti-nutritional factors. Phytate and oxalate can reduce mineral bioavailability through mineral binding and formation of poorly soluble complexes (Ombeni *et al.,* 2024). Although the present findings suggest that oven-drying may concentrate anti-nutritional compounds,

their nutritional significance depends on their absolute concentrations, bioavailability and quantity consumed.

Table 5: Anti-nutritional factors in fresh and oven-dried Cirina forda larvae

Sample	Phytate (%)	Saponin (%)	Tannin (mg/100g)	Alkaloid (%)	Oxalate (%)
Fresh C. forda	4.22 ± 0.03^{b}	1.99 ± 0.03^{b}	1.37 ± 0.03^{b}	3.27 ± 0.03^{b}	8.21 ± 0.03^{b}
Dried C. forda	6.74 ± 0.03^{a}	4.20 ± 0.30^{a}	1.44 ± 0.08^{a}	6.33 ± 0.03^{a}	11.53 ± 0.03^{a}

Values are means ± SD; means within a column bearing different superscripts differ significantly ($p \leq 0.05$, DMRT).

CONCLUSION

This study has established *Cirina forda* as a Nutritious and Socio-economic valuable Non-Wood Forest Product in Southern Taraba State, Nigeria. Oven drying resulted in a high concentration of crude protein and minerals, especially iron and zinc, which could be beneficial for storage stability, but it also resulted in a significant decrease in moisture in the product, as well as an increase in anti-nutrients, such as thiamine, phytate and oxalate, which also resulted in a significant increase in anti-nutrients such as thiamine, phytate and oxalate, indicating a nutritional trade-off associated with the traditional drying method. Socio-economically, the female respondents outnumbered the males, with the highest number of respondents being those in the 18–25-year age group and those with secondary education; a small number of respondents also had income from *C. forda* collection and trade, but mostly as an additional income. With optimized processing and strengthened market structures, *C. forda* has great potential as a nutritious food source, rich in proteins and micronutrients as well as a source of rural income.

Recommendations

On the basis of the results, the following recommendations are given:

1. Dried *C. forda* is a plant that would be worth further study as being useful for protein and micronutrient fortification of food products.
2. Phytase treatment and other processing methods to improve nutrient retention and reduce phytate and oxalate should be tested in the future.
3. Sustainable harvesting training and, if possible, domestication or semi-domestication trials should be continued to lower pressure on wild resource during the peak of the rainy season and to increase potential harvest outside of the rainy season.

4. Cooperative marketing hubs, aggregation centers and better market information systems need to be set up to minimize the reliance of collectors on middlemen and to enhance their access to and participation in the trading margins.
5. Safety, acceptability, bioavailability and processing stability of *C. forda* should be evaluated in depth, before considering its use in food-security and nutrition programmes.

REFERENCES

Adepoju, O. T., & Daboh, O. O. (2013). Nutrient composition of *Cirina forda* (Westwood)-enriched complementary foods. *Annals of Nutrition and Metabolism, 63*(1–2), 139–144. https://doi.org/10.1159/000353885

Adepoju, O. T., & Daboh, O. O. (2020a). Consumer acceptability and nutrient content of Westwood (*Cirina forda*) larva-enriched *Amaranthus hybridus* vegetable soups. *African Journal of Food Science, 14*(8), 244–255. https://doi.org/10.5897/AJFS2020.1945

Adepoju, O. T., & Daboh, O. O. (2020b). Knowledge and consumption pattern of *Cirina forda* (Westwood) larva in two local government areas of Oyo State, Nigeria. *Nigerian Journal of Nutritional Sciences, 41*(1). https://journal.nutritionnigeria.org/papers/volume-41/issue-1/knowledge-and-consumption-pattern-of-cirina-forda-westwood-larva-in-two-local-government-areas-of-oyo-state-nigeria/

Agbidye, F. S., Ofuya, T. I., & Akindele, S. O. (2009). Marketability and nutritional qualities of some edible forest insects in Benue State, Nigeria. *Pakistan Journal of Nutrition, 8*(7), 917–922. https://doi.org/10.3923/pjn.2009.917.922

Aigbedion-Atalor, P. O., Fening, K. O., Adeyemi, A. O., Idemudia, I., Ojukwu, K. C., Nwobodo, M. A., Sunday, O., Isiogu, N. C., & Oke, A. O. (2024). Regenerative edible insects for food, feed, and sustainable livelihoods in Nigeria: Consumption, potential and prospects. *Future Foods, 9*, Article 100309. https://doi.org/10.1016/j.fufo.2024.100309

Asa, P. S., Kanati, M., & Jibo, A. (2024). Analysis of rainfall trends and changes for sustainable agricultural planning in Southern Taraba, Northeast Nigeria. *Eastern Journal of Agricultural and Biological Sciences, 4*(1), 92–105. https://www.qabasjournals.com/index.php/ejabs/article/view/295

Asa, P. S., & Yohanna, L. (2024). Exploring spatial and temporal temperature trends and characteristics for sustainable agricultural planning in Southern Taraba. *Earth Sciences, 13*(6), 239–247. https://doi.org/10.11648/j.earth.20241306.11

Association of Official Analytical Chemists International. (2012a). Official method 985.35: Minerals in infant formula, enteral products, and pet foods: Atomic absorption spectrophotometric method. In *Official methods of analysis of AOAC International* (19th ed.).

Association of Official Analytical Chemists International. (2012b). *Official methods of analysis of AOAC International* (19th ed.).

Atowa, C. O., Okoro, B. C., Umego, E. C., Atowa, A. O., Emmanuel, O., Ude, V. C., & Ugbogu, E. A. (2021). Nutritional values of *Zonocerus variegatus*, *Macrotermes bellicosus* and *Cirina forda* insects: Mineral composition, fatty acids and amino acid profiles. *Scientific African, 12*, Article e00798. https://doi.org/10.1016/j.sciaf.2021.e00798

Chidozie Ogwu, M. (2025). Entomophagy through a cultural lens: Traditions, barriers, and opportunities. In M. Chidozie Ogwu & S. Chibueze Izah (Eds.), *Edible insects: Nutritional benefits, culinary innovations and sustainability* (pp. 325–344). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-90087-7_14

Derebe, B., & Alemu, A. (2023). Non-timber forest product types and its income contribution to rural households in the Horn of Africa: A systematic review. *Forest Science and Technology, 19*(3), 210–220. https://doi.org/10.1080/21580103.2023.2231963

Edah, B., & Owolabi, O. D. (2024). Nutritional and antinutritional composition of defatted emperor moth (*Cirina forda*) larvae meal: A nutritional food source rich in amino acids, fatty acids, and minerals. *Nigeria Agricultural Journal, 54*(2), 202–207.

Food and Agriculture Organization of the United Nations. (2024, November 11). *33.1 million Nigerians projected to be food insecure in 2025*. https://www.fao.org/nigeria/news/detail/33.1-million-nigerians-projected-to-be-food-insecure-in-2025/en

Gachihi, A., Tanga, C., Nyambaka, H., & Kimiywe, J. (2023). Effect of processing methods on nutrient and anti-nutrient composition of grasshopper and termites. *CyTA – Journal of Food, 21*(1), 745–750. https://doi.org/10.1080/19476337.2023.2281984

Hlongwane, Z. T., Slotow, R., & Munyai, T. C. (2020). Nutritional composition of edible insects consumed in Africa: A systematic review. *Nutrients, 12*(9), Article 2786. https://doi.org/10.3390/nu12092786

Kosoe, E. A., Fagariba, C. J., Kaburi, S. A., & Chidozie Ogwu, M. (2025). Nutritional composition of edible insects. In M. Chidozie Ogwu & S. Chibueze Izah (Eds.), *Edible insects: Nutritional benefits, culinary innovations and sustainability* (pp. 21–43). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-90087-7_2

Kusia, E. S., Borgemeister, C., & Subramanian, S. (2023). A review of edible Saturniidae (Lepidoptera) caterpillars in Africa. *CABI Agriculture and Bioscience, 4*, Article 43. https://doi.org/10.1186/s43170-023-00186-y

Li, M., Mao, C., Li, X., Jiang, L., Zhang, W., Li, M., Liu, H., Fang, Y., Liu, S., Yang, G., & Hou, X. (2023). Edible insects: A new sustainable nutritional resource worth promoting. *Foods, 12*(22), Article 4073. https://doi.org/10.3390/foods12224073

Lu, M., Zhu, C., Smetana, S., Zhao, M., Zhang, H., Zhang, F., & Du, Y. (2024). Minerals in edible insects: A review of content and potential for sustainable sourcing. *Food Science and Human Wellness, 13*(1), 65–74. https://doi.org/10.26599/FSHW.2022.9250005

Matiza Ruzengwe, F., Nyarugwe, S. P., Manditsera, F. A., Mubaiwa, J., Cottin, S., Matsungo, T. M., Chopera, P., Ranawana, V., Fiore, A., & Macheka, L. (2022). Contribution of edible insects to improved food and nutrition security: A review. *International Journal of Food Science & Technology, 57*(10), 6257–6269. https://doi.org/10.1111/ijfs.15570

Mutungi, C., Irungu, F. G., Nduko, J., Mutua, F., Affognon, H., Nakimbugwe, D., Ekesi, S., & Fiaboe, K. K. M. (2019). Postharvest processes of edible insects in Africa: A review of processing methods, and the implications for nutrition, safety and new products development. *Critical Reviews in Food Science and Nutrition, 59*(2), 276–298. https://doi.org/10.1080/10408398.2017.1365330

Muvatsi, P., Snook, L. K., Morgan, G., & Kahindo, J. M. (2021). The yield of edible caterpillars *Imbrasia oyemensis* and *Cirina forda* from timber trees logged on concessions in the Democratic Republic of the Congo: A contribution to managing tropical forests for multiple resources. *Trees, Forests and People, 4*, Article 100079. https://doi.org/10.1016/j.tfp.2021.100079

Nemadodzi, L. E., Managa, G. M., & Prinsloo, G. (2023). The use of *Gonimbrasia belina* (Westwood, 1849) and *Cirina forda* (Westwood, 1849) caterpillars (Lepidoptera: Saturniidae) as food sources and income generators in Africa. *Foods, 12*(11), Article 2184. https://doi.org/10.3390/foods12112184

Oguche, J. A., Gadzama, G. I., Twan, S. M., & Faith, U. J. (2024). Effect of different processing methods on the nutritional and anti-nutritional factor of *Cirina forda* (Westwood) larvae. *African Journal of Biology and Medical Research, 7*(2), 198–208. https://doi.org/10.52589/AJBMR-DSA1LJA1

Ombeni, J. B., Conti, M. V., Cena, H., & Munyuli, T. (2024). Potential of dried edible caterpillars (Lepidoptera: Saturniidae) vending on local markets to improve mineral suitability in the diet of the population in Democratic Republic of the Congo. *International Journal on Food, Agriculture and Natural Resources, 5*(2), 10–19. https://doi.org/10.46676/ij-fanres.v5i2.252

Peshuk, L. V., Kyrylov, Y. E., Ibatullin, I. I., & Marenkov, O. M. (2022). Entomophagy as a promising and new protein source of the future for solving food and fodder security problems. *Journal of Chemistry and Technologies, 30*(4), 627–638. https://doi.org/10.15421/jchemtech.v30i4.271592

Rumpold, B. A., & Schlüter, O. K. (2013). Nutritional composition and safety aspects of edible insects. *Molecular Nutrition & Food Research, 57*(5), 802–823. https://doi.org/10.1002/mnfr.201200735

Sadaf, A., Raza, N., Mehmood, M. A., Shahbaz, M., Farooq, U., Ashfaq, M., & Fawaz, M. S. (2026). A multidimensional review of nutrition, environment and socio-cultural acceptance of edible insects in Southeast Asia. *British Food Journal*, 1–26. https://doi.org/10.1108/BFJ-09-2025-1307

Spitsyn, V. M., Potapov, G. S., & Spitsyna, E. A. (2021). The morphology of preimaginal stages and male genitalia of *Cirina forda* (Westwood, 1849) (Lepidoptera: Saturniidae). *Ecologica Montenegrina, 45*, 12–15. https://www.biotaxa.org/em/article/view/70828