



**Qualitative detection of frying oil composition used for fried grasshopper (*Oedalense senegalenes krauss*) using FTIR spectra in Maiduguri, Borno state, Nigeria.**

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**Abstract**

*Grasshopper is a micro livestock, rich in animal protein that is consumed as a delicacy, processed using deep-frying as a popular cooking method. The 100 g each of fried grasshopper (*Oedalense senegalenes krauss*) consisted of 4 treatments of laboratory single session deep-fried grasshoppers in covered utensils using commercial refined vegetable oil at 160<sup>0</sup>C for 2 minutes were used as control; while non-control samples were locally purchased from 3 ready-to-eat repeated-sessions of deep-fried grasshopper retail outlets in Maiduguri opposite Post Office, Wulari and Bulumkuttu respectively. Samples of grasshoppers were ground to powder and oil was extracted using soxhlet method and analyzed for quality to identify primary functional groups using Fourier Transform Infrared (FTIR) spectrometer. Distance variation in aberration characteristics of non-control oils indicated strong wide band for the O-H stretch around 2540 cm<sup>-1</sup> (2500-3300 cm<sup>-1</sup>) for the carbonyl functional group and a strong C-N stretch (1180-1360 cm<sup>-1</sup>) which produced heterocyclic aromatic amine (HAA). Both functional groups constitute a serious health risk in overheated oil. For food safety and public health advocacy when cooking, frying oil should be discarded after one time use.*

**Keywords:** Grasshopper, Oil composition FTIR, Deep-frying, Maiduguri.

**Introduction**

The intentional cultivation of insects and edible arthropods for human food, referred to as micro livestock is now emerging in animal husbandry as an ecologically sound concept. Nigeria is an insect eating (entomophagy) nation (Ademolu, 2018). The most abundant insect in the world with more than 20000 species is the *Orthoptera* order which includes grasshoppers (920 species) which for its accessibility and price, the most which consumed (Ramos-Elordmy *et al.*, 2012). According to Kim *et al.*, (2019) 100 g of insects contain an equivalent amount of energy to 100 g of meat. Incorporating edible insects into the food system has the potential to provide a sustainable solution to global food and feed challenges while also addressing

developmental setbacks in developing countries (Liceaga, 2021). The main obstacle to the inclusion of insects in human diet is consumer perception in developing countries (Lange and Nakamura, 2023). It is predicted that the market for edible insects would now grow from \$83.4 billion to \$130.3 billion by 2024 (Cheseto *et al.*, 2020). In the United States, the Food and Drug Administration (FDA) has categorized insects as a “food additive” under the Food, Drug and Cosmetic Act, meaning that any food product containing insects must be approved by the FDA before it can be sold (FDA, 2018). Rearing and using insects as food and feed is economically viable with limited or no greenhouse gas emission (Penedo *et al.*, 2022).

Grasshoppers are crop pests and swarms outbreaks could occur but, are mostly sedentary, with less damage and can be easily controlled and managed with interventions such as pesticides within a kilometer in comparison to locust. (Zhang *et al.*, 2019). According to Van Huis *et al.*, (2013) grasshoppers collected in millet fields in West Africa fetched a higher price in local market than millet itself. Picking and collection of grasshoppers from the wild and crop farms has made such human activities as an effective cultural control measure which is relatively a very hazardous method than chemical and bush burning (Sharah, 2012). Value added grasshoppers command higher premium prices particularly when sold in off-season market (Donkor, 2020). Grasshopper is rich in animal protein. Grasshopper now eaten fried with species, gained cognizance as an important delicacy for human consumption (Makinta, 2014). The Sahelian grasshopper (*Oedalens senegalensis krauss*) common in Maiduguri is obtained from the forest in the arid tropical ecosystems (Zira *et al.*, 2021).

It is common knowledge that the ready-to-eat grasshoppers in Maiduguri were deep fried in vegetable oils using open utensils, as local cooks did not discharge frying oil after each day's multiple sessions of deep frying at uncontrolled high temperatures (>160°C for >2mins/frying session), but preferred to complete the remaining in frying pots by topping up fresh oil to make for sufficient quantity for frying at next day's sessions. According to Tamizi *et al.*, (2016) vegetable oil is extensively utilized in various frying applications, the preservation of its quality attributes as a result of oil deterioration in quality and multiple frying processes is still a concern to food processors and consumers due to food safety.

The Fourier Transform Infrared (FTIR) spectroscopy provides the qualitative data of

an oil sample by identifying the organic group present via vibration of molecular bonds due to the presence of certain radical groups in the infrared spectrum of characteristic wavenumbers (Mashodi *et al.*, 2020). The FTIR methods are some of those employed frequently to detect fraud and adulteration of oil and fats from different sources, hence monitoring of purity of oils and fats has therefore become an integral part of quality assurance in the food industry (Marikkar, 2022).

The use of FTIR spectroscopy as a quality control tool is yet to be implemented by vegetable oil industry in Nigeria. The aim of this study was focused on qualitative detection of frying oil used to process ready-to-eat grasshopper *O. senegalensis* using FTIR spectroscopy.

### Materials and Methods

The experimental site is located in Maiduguri within the Sahelian Zone of Nigeria, Latitude 11°50'48.91N and Longitude 13°9'25.63E, with mean values of temperature 34.74°C, 39.34mm rainfall and 35.24% humidity respectively. Random sampling replicated thrice in a completely randomized design were 4 treatments each of commercial refined vegetable oil of ISO 900 quality certification, Frying oil of single deep-frying session at 160°C for 2 minutes in covered utensils in laboratory of 100g of fresh *O. senegalensis* as control; and each of 100g of grasshopper samples were purchased locally from three non-control sample sites of retail locations-opposite Post Office, Wulari, and Bulumkuttu, respectively. Such ready-to-eat grasshoppers are presented for sale and consumed by the population living in the city of Maiduguri, Borno State, North Eastern Nigeria.

Grasshoppers from non-control sampling sites were transported in asphatic container to laboratory, and all treatment samples were

frozen at  $-4^{\circ}\text{C}$  for subsequent analyses. According to methods of Escamilla-Rosales *et al.*, (2019) all treatment samples were defrosted at  $25^{\circ}\text{C}$  and dehydrated in dry oven at  $70^{\circ}\text{C}$  for 4 hours homogenized and sieved separately at particle sizes of 2mm.

### Oil Extraction

According to Jongema, (2015) 1g homogenized samples of *O. senegalensis* were separately deep-seated inside porous cartridge and introduced in a soxhlet extraction equipment using petroleum ether at  $40^{\circ}\text{C}$  for 4hours, thereafter oil was separated from petroleum ether using roto separator at  $50^{\circ}\text{C}$ .

### Determination of Functional Group Using FTIR Spectrophotometer

The quality of extracted oil analyzed was measured using an FTIR spectrophotometer (BUCK Scientific model M530) to identify the primary functional groups discovered. According to the methods of Mustapha *et al.* (2021) and Mustapha and Surgun (2021) the samples were placed in contact with KBr screen and FTIR spectra were collected in frequency  $4000\text{-}400\text{cm}^{-1}$  by coadding 32 scans at resolution of  $4\text{cm}^{-1}$ . All spectra were rationed against a background spectrum was detected. These spectra were recorded as absorbance values at each data point in triplicate.

### Results and Discussion

The transmittance frequency the was no absorption above 100% results show spectral wave numbers presented in this study, (Table 1) are comparable with the FTIR spectrum chart as reported by Thain, (2022). The bands produced by major functional groups ( $500 - 4000\text{ cm}^{-1}$ ) is in the mid-IR region with 4 identifiable regions of characteristic peaks. Further, that ( $500 - 1500\text{ cm}^{-1}$ ) is within the fingerprint region with skeletal vibrations; ( $1500 - 2000\text{cm}^{-1}$ ) is region of double bonds; ( $2000 - 2500\text{ cm}^{-1}$ ) is region of triple bonds;

while ( $2500 - 4000\text{ cm}^{-1}$ ) is the region bond stretched respectively.

In Figures 1-4, grasshoppers fried in non-control oils presented spectral wave numbers of 1009.31, 1000.84, 1181.38 and  $1202.15\text{ cm}^{-1}$  respectively. According to Awogbemi *et al.* (2019) this is an indication of the presence of similar chemical groups in their composition. Non-control oils presented noticeable aberration characteristics of alcohol C-O stretch when viewed against control. These are comparable to report of Tan *et al.* (2022) that the spectral alteration of these oils is due to the degradation of their properties from prolonged exposure to high heat during frying. Alcohol functional group have characteristics IR absorption associated with the C-O stretching vibrations which is a strong bond. Reports of Liu *et al.* (2012) postulated that during frying gradual increase in alcohol promoted oxidation of unsaturated fatty acids. Mid-IR spectroscopy has been successfully used for identification of adulteration in vegetable oils, accordingly the adulteration of pure oils can be detected using discriminant analysis through the fingerprint region which falls under  $1000\text{-}1500\text{ cm}^{-1}$  (Rohman *et al.*, 2010).

Prolong repeated frying oils effects on non-control grasshoppers from Wulari and Bulumkuttu ( $1180\text{-}1360\text{ cm}^{-1}$ ) can produce compounds namely heterocyclic aromatic amines (HAA) that are detrimental to the health of consumers and recooking of oil results in an increase in free carboxyl acids (Mittu *et al.*, 2023). In Table 1, carboxylic acids (a carbonyl group) shows a strong wide band for the O-H stretch that are easy to identify in non-control oils around  $2540\text{cm}^{-1}$  ( $2500\text{-}3300\text{cm}^{-1}$ ). According to Muhizi, (2014) the presence of carboxyl groups in overheated oil may constitute a serious risk to the human body. Reports of Lim *et al.* (2018) indicated that oxidized vegetable oil heated over  $230^{\circ}\text{C}$  produced hydrogen peroxide,

which could over time diminish to other secondary oxidation compounds such as aldehydes and ketones, which are harmful to health.

Locally in Maiduguri frying grasshopper were performed in non-covered utensils. According to Muhizi, (2014) air was in direct contact with both vegetable oil and samples, therefore in conjunction with oxygen, further degradation of the oil leads to formation of various by-products with suspected side effects to human health.

### Conclusion

When frying grasshopper, it should be undertaken in covered utensils and all frying oils used for frying should be discarded after one time of use to avoid consuming toxic compounds with grasshopper.

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### References

Ademolu, K. O. (2018). Edible insect. *In: Animal husbandry: Microlivestock*, Ebenso, I.E. and Mohammed, I.D. (Eds). 1<sup>st</sup> Edn. Lagos: MIDA Communication, Chapter 1: 138-154.

Awogbemi, O., Onuh, E. I. and Komolape, C. A. (2019). Thermal degradation and spectroscopic study of neat palm oil, waste palm oil methyl ester. *IOP conference series: Earth and Environmental Sciences*, 331: 21-31.

Cheseto, X., Baleba, S. B. S., Tanga, C. M., Kelemu, S. and Torto, B. (2020). Chemistry and sensory characterization of a bakery product preferred with oils from African edible insects. *Foods*, 9:800-809.

Donkor, E., Mithofer, D., Mbeche, R., Kinyuw, J. and Nakimbugwe, D. (2020). Value addition and off-season market participation among retailers in the grasshopper value chain in Central Uganda. Tropenteg conference, Germany (presented online).

Escamilla-Rosales, M.F. *et al.* (2019). Comparison of the proximal chemical and fatty acid composition of the fried grasshopper's (*Orthoptera*) dish. *European Food Research Technology*, Publish online 21<sup>st</sup> march 2019.

FDA (Food and Drug Administration) (2018). *Guideline for industry: num 255*. The use of an alternate name for potentially allergenic ingredients in the labelling of human food and animal feed (FDA). Available at [www.fda.gov/](http://www.fda.gov/)

Jongema, E. (2015) *World list of edible insects*. Wageningen University, Wageningen pp43-49

Kim, T.K., Young, H.I., Kim, Y.B., Kim, H.W. and Choi, Y.S. (2019). Edible insects as a protein source: a review of public perception, processing technology and research trends. *Food Science of Animal Resources*, 39:521-540

Lange, K. W. and Nakamura, Y. (2023). Potential contribution of edible insects to sustainable consumption and production. *Frontiers in Sustainability*, 4:1112950

Liceaga, A. M. (2021). Processing insects for use in the food industry. *Current Option in Insects Science*, 48:32-36.

Liu, R., Qi, N., Sun, J., Chen, H., Zhang, N. and Jun, B. (2012). Effects of frying conditions on volatile composition and odour characteristics of fried pepper (*Zanthoxylum bungeannum*) oil. *Foods*, 11:1661

- Lim, S.Y., Abdul Mutalib, M.S., Khaza'ai, H. and Chang, S. K. (2018). Detection of fresh palm oil adulteration with recycled cooking oil using fatty acid composition and FTIR spectral analysis, *International Journal of Food Properties*, 21 (1): 2428-2451.
- Makinta, U., Mohammed, S.T., Mamman, B.Y. and Makinta, B.G. (2014). Analysis of cost and returns of fried grasshopper marketing in Maiduguri metropolis, Borno State, Nigeria. *Agriculture and Food Security*, 1 (1): 31-35.
- Marikkar, J. M. N. (2022). Adulteration in oilseed and fats industry. In: *Recent advances in edible fats and oils technology*, Lee et al., (ed) Singapore: Springer 17:464-480.
- Mashodi, N., Rahim, N. Y., Mohamed, N. and Asman, S. (2020). Evaluation of extra virgin olive oil adulteration with edible oils using ATR-FTIR spectroscopy *Malaysian Journal of Applied Science*, 5:35-44.
- Mittu, B., Chaturvedi, A. and Sharma, R. (2023). In: *Frying technology*, Singh, A., Wani, S. A. and Kumar, R. (Eds). 1<sup>st</sup> Edn. Boca Raton: CRC Press
- Muhizi, T. (2014). NMR and FTIR analysis of overheated cooking oil. *Oriental Journal of Chemistry*, 30(2): 643-649.
- Mustapha, L. M. and Surgun, S. (2021). Comparative analysis and characterization of biodiesel production from *Moringa oleifera*, *Glycine max* and *Jatropha curcas* seed oils using homogenous catalyst. *International Journal of Advances in Engineering and Management*, 3: 512-523.
- Mustapha, L. M., Shago, M. I., Burhanuddin, R. H. and Suleiman, G. (2021). Physicochemical analysis and characterization of biodiesel production from *Ricinus communis* seed oil. *FUDMA Journal of Sciences*, 5 (1): 404-410.
- Penedo, A.O., Bucher, S., Torre, D., Cotze, F., Bonner, T. A. and Bruck, W.M. (2022). The consumption of insects in Switzerland: University IT-based perspectives of entomophagy. *Foods* 11: 2771-2883
- Ramos-Elorduy, J. M., Pino, J. M. and Camacho, V.H.M. (2012). Could grasshoppers be a nutritive meal? *Food and Nutrition Science*, 3:164
- Rohman, A., Cheman, Y.B., Ismail, A. and Puziah, A. T. (2010). FTIR spectroscopy combined with chemometrics for analysis of lard in some vegetable oils. *Cyta- Journal of Food*, 9:96-101.
- Shara, H. A. (2012). The driving force behind increasing grasshopper frying business in Maiduguri: profitability or joblessness? *International Journal of Economic Development Research and Investment*, 3(2): 110-117.
- Tan, S. L., Meriam Suhaimy, S. H. and Abd Sanand, N. A. (2022). Evaluation of fresh palm oil adulteration with recycled cooking oil using GC-MS and ATR-FTIR spectroscopy- a review. *Czech Journal of Food Science*, 40:1 - 14.
- Tarmizi, A. H. A., Ismail, R. and Kauntom, A. (2016). Effect of frying on the palm oil quality attributes –a review. *Journal of Oil Palm Research*, 28 (2): 143-153.
- Thain, S. (2022). *IR spectroscopy and FTIR spectroscopy: How an FTIR spectrometer works and FTIR analysis*. [www.technologynetwork.com](http://www.technologynetwork.com)
- Van Huis, A., Van Uterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G. and



Vantomme, P. (2013). *Edible insects: future prospects for food and food security*. FAO Forestry paper num 171, Rome: Food and Agriculture Organisation (FAO) pp.187.

Zhang, L., Lecoq, M., Latchinshy, A. and Hunter, D. (2019). Locust and grasshopper management. *Annual Review of Entomology*, 46:15-34.

Zang, C.X., XI, J., MA, Y.X. and Wang, X.D. (2021). Effect of deep fat frying conditions on the formation of heterocyclic aromatic amines in chicken meat. *Food Science and Technology*, 42: 67321

Zira, B.D., Lawal, S. and Bukar, M.M. (2021). Analysis of grasshopper (*O. Senegalensis Krauss*) marketing in Sudano Sahelian Region of Nigeria. *Nigeria Journal of Animal Science and Technology*, 4 (1): 131-136.

**Table 1: FTIR spectra from grasshopper *O. Senegalensis* frying oil in Maiduguri**

	<b>Frequency (cm<sup>-1</sup>)</b>	<b>Intensity</b>	<b>Vibration mode</b>	<b>Functional group</b>
1	675-900	medium	-C-H out of plane bending	Mono subt. Benzene
2	960-1000	strong	=C-H bending	Benzene
3	1180-1260	strong	-C-O stretch	Phenol
4	1180-1360	strong	-C-N stretch	Amines
5	1500-1600	medium	-C=C- stretch	Aromatic
6	1680-1740	strong	-C=O stretch	Ketones
7	2500-3300	medium	-OH stretch	Carboxylic acid
8	2800-3000	medium	-O-H stretch	Alkane
9	3300-3500	medium	-N-H stretch	Amines cabolate NH <sub>2</sub>
10	3600-3650	medium	-O-H stretch	Alcohol
11	>3650	strong	-O-H stretch	Hydroxyl

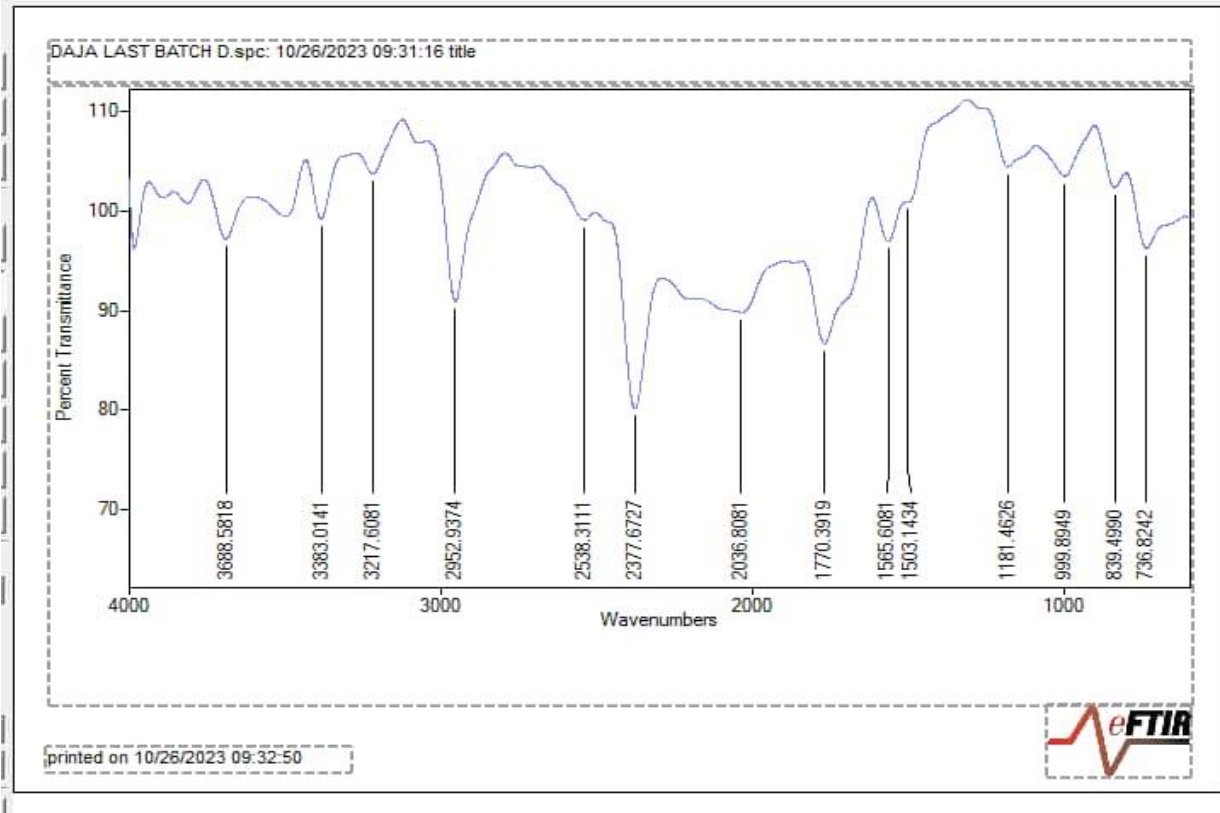


Figure 1: Laboratory (control) grasshopper *O. senegalensis* deep-frying oil FTIR analysis

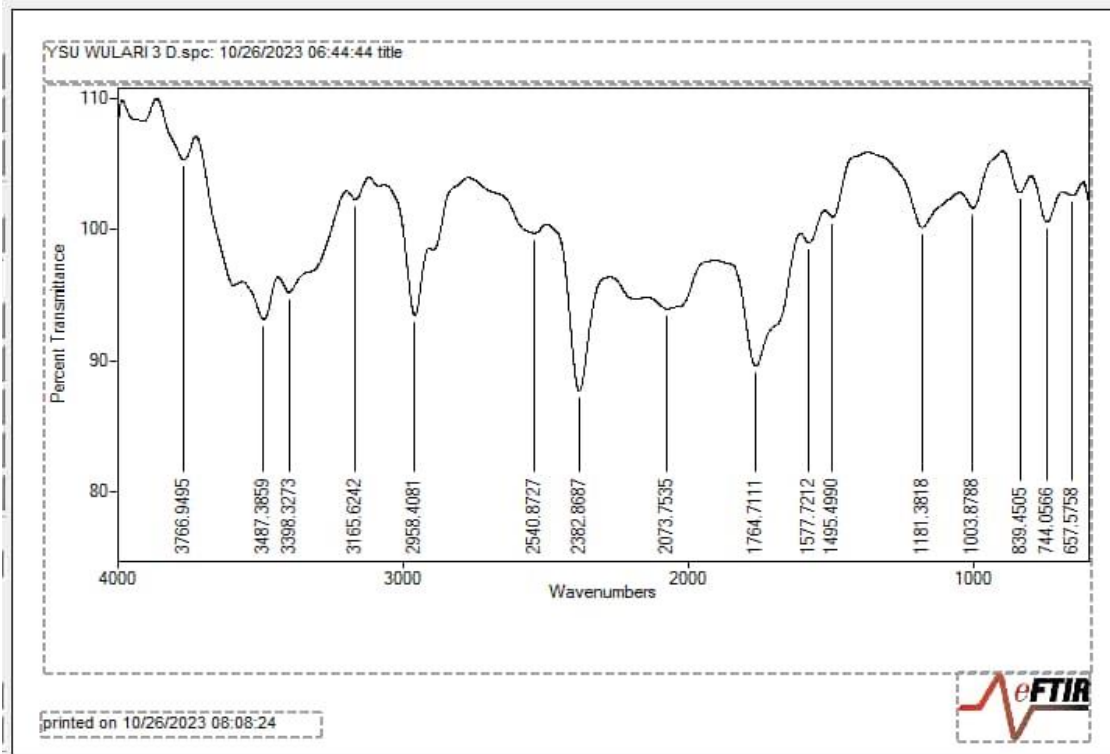


Figure 2: Wulari grasshopper *O. senegalensis* deep-frying oil FTIR analysis

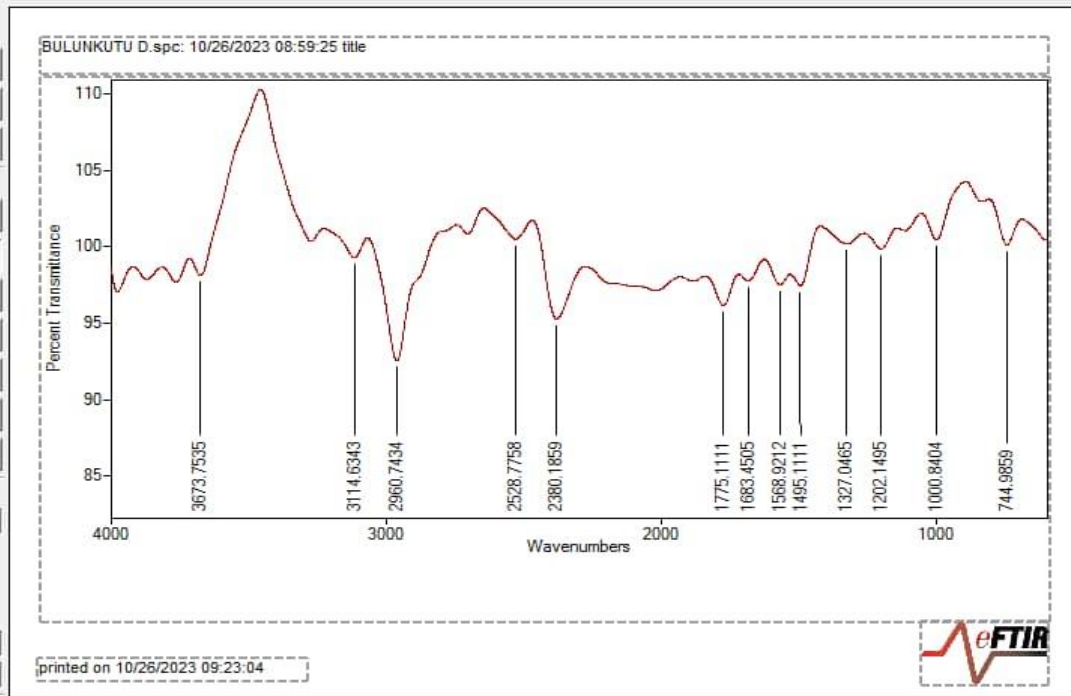


Figure 3: Bulumkuttu grasshopper *O. senegalensis* deep-frying oil FTIR analysis

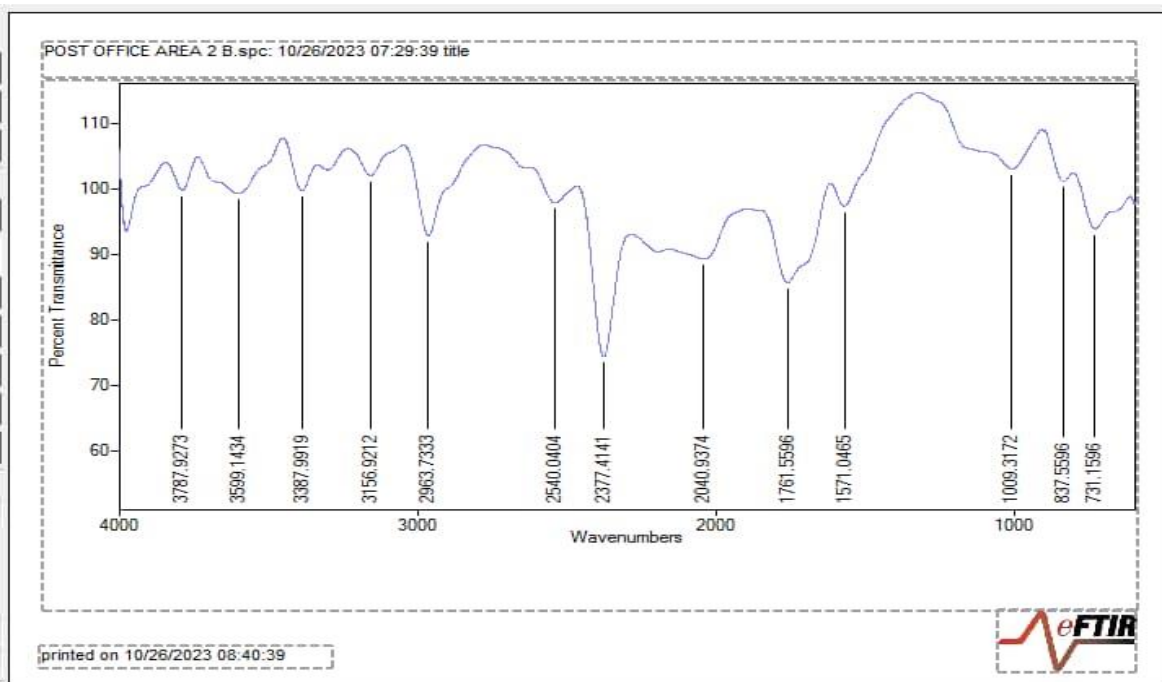


Figure 4: Opposite Post Office grasshopper *O. senegalensis* deep-frying oil FTIR analysis