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Assessment of the Persistent Organic Compounds Residual Level of *Telfaria occidentalis* Hook F. Leaves (Ugu) Cultivated in the Federal Capital Territory, Abuja - Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study investigated persistent organic compounds residue level in *Telfaria occidentalis* Hook F. Leaves (Ugu) cultivated in the Federal Capital Territory, Abuja Nigeria. *T. occidentalis* was collected from 12 farms, 2 each per Area Council using a circular grid of 20m apart. Random sampling technique was used to collect samples *T. occidentalis* (Ugu) leaves at six different spots

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within the farm to form composite sample during the rainy season (August, 2023). The POCs residue levels were determined using Gas Chromatography-Electron Capture Detector (GC-ECD). Alpha-BHC, Beta-BHC, Gamma-BHC, Aldrin, Heptachlor, Endrin, DDT (Dichlorodiphenyltrichloroethane) and Endosulfan Sulfate were recorded in *T. occidentalis* across the Area Councils of all these, Heptachlor has the highest concentration of 15.67mg/kg, followed by Endrin with 15.25mg/kg, Beta – BHC with 13.87mg/kg, Endosulfan Sulfate with 8.56mg/kg, DDT with 7.49mg/kg, Alpha – BHC with 4.86mg/kg, Aldrin with 2.17mg/kg and the lowest concentration is that of Gamma – BHC with o.49mg/kg. Occurrence of these POCs was also ranked across the Area Councils where some Area Council ranked first in some POC and closely followed by others an indication of indiscriminate use of pesticides in these Area Councils particularly those detected for which the Area Councils ranked first. There was no significant difference ($p<0.05$) in the concentrations across the six Area Councils. However, these concentrations been above Maximum Residue Limits (MRLs) permissible by the World Health Organization/ Food and Agricultural Organization (WHO/FAO) and National Environmental standard and Regulations Enforcement Agency (NESREA) which implies that there is a potential health risk for human and animals that consume these vegetables however, the extent of health effects will depend on the quantity and frequency of consumption and this calls for strict regulation of the application of the pesticides in farms.

Keywords: Persistent; occurrence; Telfairia occidentalis; health risk; farm.

1. INTRODUCTION

Telfairia occidentalis is a darkish green leafy vegetable that belong to the family cucurbitaceae a dioceous, perennial vine shrub which is partially drought-tolerant (Horsfall and Spiff 2005). It is commonly called Fluted pumpkin and an important vegetable crop grown in Nigeria. It is a tropical vine which originated from Tropical West Africa (Akoroda, 1990). Cultivated mainly in West African countries especially Nigeria, Ghana and Sierra-Leone for its leaves and seeds (Akoroda, 1990). It is widely grown in the South-Eastern part of Nigeria as a leaf and seed vegetable. Its versatility for use in the preparation of various dishes makes it increasingly popular in Nigeria hence it is referred to as “Ugu” in Igbo, “Ubon” in Efik and “Eweroko” in Yoruba (Denton et al., 2000).

Vegetables are full of essential vitamins, minerals, and antioxidants that provide many important health benefits to the body. They are a good source of dietary fibre, a type of carbohydrate that helps pass food through digestive system Botwe et al*.* (2011), fibre may also improve vitamin and mineral absorption in the body which could potentially raise daily energy levels. According to (Omale and Ugwu 2011), many green leafy vegetables contain potassium which helps the kidney filter sodium out of the body more efficiently, which can reduce blood pressure. Botwe et al*.* (2011) also reported that vegetable consumption is usually encouraged as they are essential for a healthy and balanced diet as well as adding variety, interest and flavour to the menu.

Pests and diseases constitute a major constraint to *T. occidentalis* production, in spite of its nutritional value and importance (Rani et al., 2022; Uchechi et al., 2024). Low production or set back of the crop has been attributed to serious insect pest infestation (Emosairue, 2007). The insects feed on the leaves of the crop thereby creating tattered holes on them and defoliation of the leaves when infestation is severe (Emosairue, 2007). They also contribute to perforation of the leaves, leaf scarification all of which can result in reduction of the photosynthetic ability of the plant, reduction in yield as well as vector of other plant diseases (Emosairue, 2007).

Waldrum et al. (1996) defined a pesticide as any product that kills or control various types of pests (plant or animal that is harmful to man or the environment), and that pesticides are used in agriculture to protect crops against insects, fungi, weeds and other pests as well as to protect public health in controlling the vectors of tropical diseases like mosquitoes.

Persistent Organic Pollutants (POP) are organic compounds that are resistant to environmental degradation through chemical, biological and photolytic processes (Ritter et al*.,2*000). They are very persistent and as a result, bioaccumulate in the plant and bodies of consumers with potential adverse impacts on human health and the

environment (Eugine and Vincent 2016). Many POPs are used as pesticides, solvents, pharmaceuticals, and industrial chemicals.

Telfairia occidentalis is one of the most important vegetables in agricultural industry, food and economy of Nigeria due to its high demand and consumption rate in various localities. Farmers of this crop testify to its economic buoyance, simple and straightforward planting method (Nwosu et al*.,* 2016). However, it is quite susceptible to a lot of diseases and pest such as *grasshoppers, aphids, beetles, bugs,* and *worms* that can easily hamper growth of the crop and destroy the farm.

In the Federal Capital Territory, *Telfairia occidentalis* is one of the highest consumed green vegetables hence cultivated all year round. Farmers in this area are faced with challenge of pests particularly *aphids, bugs, bettles* and *worms* which eat up or bore the leaves that affect its market value. In the bid to control these pests and improve the production, a lot of chemicals are used in the form of pesticides, herbicides and fertilizers.

This research aimed to assess the residual level of some of these commonly used persistent organic compounds (POCs) used as pesticides during *Telfaria occidentalis* (Ugu) cultivation in the Federal Capital Territory Abuja, Nigeria.

2. MATERIALS AND METHODS

Study area: The study was carried out in Federal Capital Territory (FCT) Abuja, Nigeria located between latitudes 8°25' and 9°26' North of equator and longitudes 6°45' and 7°39' East of the Greenwich Meridian (FCTA, 2022). The Federal Capital Territory has a total land mass of about 8000 sq. km: located geographically at the centre of the country (FCTA, 2022). Abuja's 2022 population is now estimated at **3,652,000**. These population estimates and projections come from the latest revision of the UN World Urbanization Prospects (UNWUP). These estimates represent the Urban agglomeration of Abuja, which typically includes Abuja's population in addition to adjacent suburban areas (UNWUP, 2022).

The FCT experiences three weather conditions annually. This includes a warm, humid rainy season and a hot dry season. In between the two seasons, there is a brief interlude of harmattan occasioned by the North East Trade Wind, with the main feature of dust haze, intensified coldness and dryness (FCTA, 2022). The rainy season begins from April and ends in October, when daytime temperatures reach 28-30°C night time lows hover around 22-23°C.

There are six Area Councils in the FCT. They are Abaji, Abuja Municipal Area Council (AMAC), Bwari, Gwagwalada, Kwali and Kuje Area Councils.

Sample collection and processing: *T. occidentalis* was collected from 12 farms, 2 each per Area Council. Random sampling technique was used to collect samples *T. occidentalis* (Ugu) leaves at six different spots within the farm to form composite sample during the raining season (August, 2023)

Extraction of Vegetable Samples: The samples were chopped to pieces with a stainless-steel knife on a clean chopping board, before they were macerated to formed paste with Forever mixer. Using QuEChERS (standing for quick, easy, cheap, effective, rugged and safe) method as described by (Miguel et al. 2022), 3.0 g portion of the homogenized sample was weighed into a 50 ml polytetrafluoroethylene (PTFE) tube, and then 3.0 ml of acetonitrile containing 1% acetic acid (v/v) was added followed by 2.0 g anhydrous sodium sulphate. The sample was shaken vigorously for 3 minutes and then centrifuged at 1500 rpm for 5 minutes.

Clean up of Vegetable Extracts: After centrifugation, the samples were cleaned up using dispersive solid-phase extraction (dSPE). 2mL of the supernatant was transferred to a 15 ml PTFE tube to which 50 mg each of silica gel with 150g Na_2SO4 was added and vortexed for 30 seconds and then centrifuged for 1 minute at 1500 rpm. The clear extract was then transferred to an auto sampler vial for GC-ECD analysis (Miguel et al. 2022).

Determination of Persistent Organic Compounds Residues: As described by (Yang et al. 2019), about 1µL was injected into the GC-ECD via an Agilent auto sampler (7683B) to the GC-ECD (Agilent 7890A) System installed with a Technokrama column DB 17(30m x 250um x 0.25um) was used for the chromatographic separation. The oven was programmed as follows: initial temperature 40˚C, 1.5 minutes, to 150˚C, 15 minutes, 5˚C/minute to 200˚C, 7.5minutes. 25˚C/minute to 290˚C with a final hold time of 12 minutes and a constant column flow rate of 1 ml/minute. The detection of the organochlorine pesticides was performed using the GC-ECD. Electron capture detector. The retention time, peak area and peak height of the sample were compared with those of the standards for quantification.

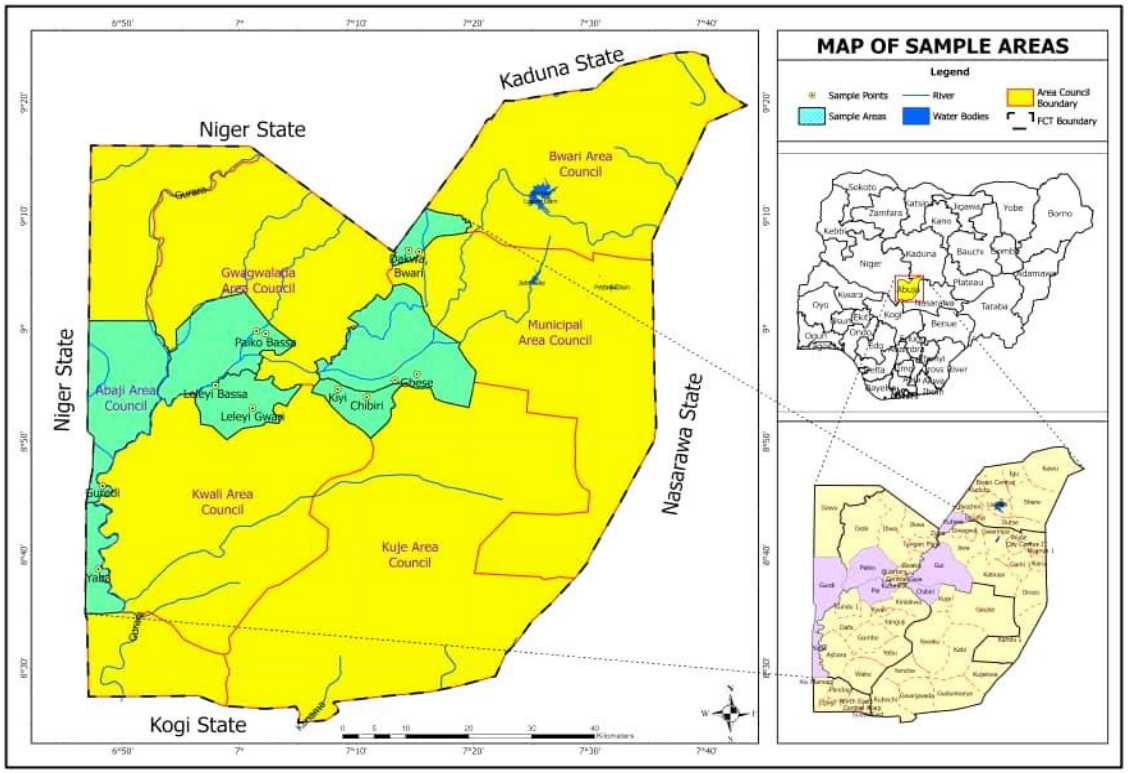

Plate 1. Map of FCT – Abuja showing the study area (Field Data) Scale: 1:50,000

Statistical analysis: Data Minitab Version and Statistical Package for Social Sciences (SPSS) version 25 was used to analyze data. Microsoft Excel version 2019 was also used for some statistical computations, The Kolmogorov Smirnov test was used to test if data were normally distributed. Other descriptive statistical tools were also used. The Spearman rank correlation Analysis was also used to compare occurrence of the POCs across Area Councils.

3. RESULTS AND DISCUSSION

The mean values of all detected Persistent Organic Compounds measured in this study ranged from 0.49 – 15.67mg/kg in *T. occidentalis* leaves as indicated across the Area Councils (Tables 1 & 2). Alpha – BHC, Beta – BHC, Gamma – BHC, Aldrin, Heptachlor, Endrin DDT and Endosulfan Sulfate were detected, however, some were not detected in some Area Councils. Generally, the detected POCs were over 10 times higher than the FAO/WHO MRL for green leafy vegetables. There was no significant difference ($p<0.05$) in the concentrations of Persistent Organic Compounds across the six Area Councils.

In Abaji Area Council, Endrin was the highest concentration recorded with 15.25±9.68mg/kg followed by Endosulfan Sulfate with 8.56±5.31mg/kg, Alpha – BHC with 4.86±4.76mg/kg and Aldrin with lowest concentration of 2.17±1.47mg/kg. All the concentrations are 305%, 86%, 97.2% and 43.4% respectively above the maximum residue limit of 0.05mg/kg, 1.00mg/kg, 0.05mg/kg and 0.05mg/kg.

Gamma – BHC, Endrin and DDT were detected in *T. occidentalis* leaves collected in AMAC. DDT was the highest concentration with 6.11±3.59mg/kg followed by Endrin with 5.23±3.05mg/kg and Gamma-BHC with lowest concentration of 3.52±1.84mg/kg. All the concentrations are 31%, 146% and 70% above the maximum residue limit of 0.02mg/kg, 0.05mg/kg and 0.05mg/kg respectively.

Bwari Area Council recorded four POCs in samples of *T. occidentalis* leaves collected. Alpha-BHC has the highest concentration of 2.51±1.27mg/kg followed by Endrin with 1.57±0.72mg/kg, Endosulfan Sulfate with 0.90±0.41mg/kg and Gamma-BHC with lowest of 0.49±0.17mg/kg all the concentrations were 50.2%, 31%, 10% and 10% respectively above the MRL of 0.05mg/kg, 0.05mg/kg 1.00mg/kg and 0.05mg/kg.

Table 1. Mean Concentration of Persistent Organic Compound in Herbage Across the Area Councils in the Rainy Season

Area Councils	Abaji	Abuja Municipal	Bwari	Gwagwalada	Kuje	Kwali	FAO/WHO MRL Codex (2019)	NESREA
POC Mean ± SEM (mg/kg)								
Alpha-BHC	4.86±4.76	ND	2.51±1.27	ND	1.68±0.46	ND	0.05	0.05
Beta-BHC	ND	ND	ND	13.86±9.38	ND	3.36±1.78	0.05	0.05
Aldrin	2.17±1.47	ND	ND	ND	ND	ND	0.05	0.05
Heptachlor	ND	ND	ND	6.02±3.56	2.43±0.60	15.67±9.53	0.02	0.05
Gamma-BHC	ND	3.52±1.84	0.49±0.17	7.21±4.52	1.13±0.16	ND	0.05	0.05
Endrin	15.25±9.68	5.23±3.05	1.57±0.72	7.21±4.52	2.81±0.81	7.29±4.39	0.05	0.05
DDT	ND	6.11±3.59	ND	7.49±4.85	1.44±0.34	ND	0.20	0.05
Endosulfan Sulfate	8.56±5.31	ND	0.90±0.41	ND	ND	ND	1.00	0.05

Key: SEM – Standard Error on the Mean
ND – Not Detected
POC – Persistent Organic Compound
FAO – Food and Agriculture Organization of the United Nations
WHO – World Health Organization
MRL – Maximum Residue Limit
NESREA- National Environmental Standards and Regulations Enforcement Agency

Table 2. Comparison of Rainy Season Persistent Organic Compound Residues in *Telfaria occidentalis* Leaves with Standard Limit

Pesticide in mg/kg	Alpha – BHC	Beta – BHC	Aldrin	Heptachlor	Gamma – BHC	Endrin	DDT	Endosulfan Sulfate
Area Councils								
Abaji	4.86	ND	2.17	ND	ND	15.25	ND	8.56
AMAC	ND	ND	ND	ND	3.52	5.23	6.11	ND
Bwari	2.51	ND	ND	ND	0.49	1.57	ND	0.90
Gwagwalada	ND	13.87	ND	6.02	7.21	7.21	7.49	ND
Kuje	1.68	ND	ND	2.43	1.13	2.81	1.44	ND
Kwali	ND	3.36	ND	15.67	ND	7.29	ND	ND
FAO/WHO MRL mg/kgCodex (2009)	0.05	0.05	0.05	0.02	0.05	0.05	0.20	1.00
NESREA	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

WHO - World Health Organization
FAO - Food and Agriculture Organization of the United Nations
MRL – Maximum Residue Limit
ND – Not Detected
AMAC- Abuja Municipal Area Council
NESREA- National Environmental Standards and Regulations Enforcement Agency

In Gwagwalada Area Council five POCs were recorded in samples of *T. occidentalis* leaves collected, Beta-BHC has the highest concentration of 13.86±9.38mg/kg, DDT with 7.49±4.85mg/kg, Gamma – BHC with 7.21±4.52mg/kg, Endrin with 7.21±4.52mg/kg and Heptachlor with lowest concentration of 6.02±3.56mg/kg all the concentrations were 277%, 38%, 144%, 144% and 303% respectively above the MRL of 0.05mg/kg, 0.20mg/kg, 0.05mg/kg, 0.05mg/kg and 0.02mg/kg.

Kuje Area Council recorded five POCs in *T. occidentalis* leaves samples collected. Endrin has the highest concentration of 2.81±0.81mg/kg followed by Heptachlor with 2.43±0.60mg/kg, Alpha-BHC with 1.68±0.46mg/kg, DDT with 1.44±0.34mg/kg and Gamma-BHC with lowest concentration of 1.13±0.16mg/kg. All the concentrations are 56%, 122%, 33.6%, 7% and 23% above the maximum residue limit of 0.05mg/kg, 0.02mg/kg, 0.05mg/kg, 0.20mg/kg and 0.05mg/kg of the detected POCs in vegetables.

Heptachlor, Endrin and Beta-BHC were the POCs detected in *T. occidentalis* leaves samples collected from Kwali Area Council with concentration 15.67±9.53mg/kg, 7.29±4.39mg/kg and 3.36±1.78mg/kg respectively. All the concentrations are 784%, 31% and 67.2% above the maximum residue limit of 0.02mg/kg, 0.05mg/kg and 0.05mg/kg in vegetables.

Persistent Organic Compounds detected in *T. occidentalis* leaves across the Area Councils was ranked in occurrence (Table 3), Abaji ranked first in Alpha – BHC 4.86±4.76mg/kg, Endrin 15.25±9.68mg/kg, Endosulfan Sulfate 8.56±5.31mg/kg and the only area council that recorded Aldrin. Gwagwalada closely ranked first in Beta – BHC 13.86±9.38mg/kg, Gamma – BHC 7.21±4.52mg/kg and DDT 7.49±4.85mg/kg while Kwali only ranked first in Heptachlor 15.67±9.53mg/kg this is an indication of indiscriminate use of pesticides in these Area Councils particularly those detected for which the Area Councils ranked first. Abuja Municipal Area Council (AMAC), Bwari and Kuje are in lower ranks in the use of these pesticides.

Table 3. Occurrence of Rainy Season Pesticide Detected in *T. occidentalis* Across FCT by Rank

Pesticides	Area Councils	Mean±SEM(mg/kg)	Rank of occurrence
Alpha - BHC	Abaji	4.86±4.76	1st
	Bwari	2.51±1.27	2nd
	Kuje	1.68±0.46	3rd
Beta - BHC	Gwagwalada	13.86±9.38	1st
	Kwali	3.36±1.78	2nd
Aldrin	Abaji	2.17±1.47	
Heptachlor	Kwali	15.67±9.53	1st
	Gwagwalada	6.02±3.56	2nd
	Kuje	2.43±0.60	3rd
Gamma - BHC	Gwagwalada	7.21±4.52	1st
	AMAC	3.52±1.84	2nd
	Kuje	1.13±0.16	3rd
	Bwari	0.49±0.17	4th
Endrin	Abaji	15.25±9.68	1st
	Kwali	7.29±4.39	2nd
	Gwagwalada	7.21±4.52	3rd
	AMAC	5.23±3.05	4th
	Kuje	2.81±0.81	5th
	Bwari	1.57±0.72	6th
DDT	Gwagwalada	7.49±4.85	1st
	AMAC	6.11±3.59	2nd
	Kuje	1.44±0.34	3rd
Endosulfan Sulfate	Abaji	8.56±5.31	1st
	Bwari	0.90±0.41	2nd

4. CONCLUSION

The results of this study revealed variable Persistent Organic Compounds (POCs) residual levels in *Telfairia occidentalis* leaves samples under investigation. Based on the results, eight POCs Alpha – BHC, Beta – BHC, Gamma – BHC, Aldrin, Heptachlor, Endrin, DDT and Endosulfan Sulfate were recorded in *T. occidentalis.*

Heptachlor had the highest concentration of 15.67±9.53mg/kg and was recorded in three Area Councils, Endrin was the second highest with 15.25±9.68mg/kg and the only POCs recorded in all the Area Councils this is an indication that Endrin based pesticides are used in all the Area Councils to protect this vegetable from pests. Beta – BHC a byproduct of Lindane ranked third with 13.86±9.38mg/kg concentration however it was recorded in only two Area Councils. The lowest concentration of 0.49±0.17mg/kg was Gamma – BHC another byproduct of Lindane recorded in four Area Councils. All these concentrations were above Maximum Residue Limits (MRLs) permissible by WHO/FAO this implies that there is a potential health risk for human and animals that consume this vegetable although the extent of health effects will depend on the quantity and frequency of consumption. This is similar to result obtained by (Ibrahim et al. 2018) in a study of organochlorine pesticides in three green leafy vegetables (pumpkin leaves, spinach leaves and sorrel leaves) in Akwanga, Nasarawa State, and the work of (Adeleye et al. 2019) who reported residue levels of organochlorine pesticides in amaranthus and fluted pumpkin in South-western Nigeria both results detected organochlorine pesticides residues levels to be above the Maximum Residue Limits (MRLs) for the vegetables investigated.

The comparison of mean concentrations of Persistent Organic Compound residues in *Telfaria occidentalis* Leaves under investigation with Standard Limit indicate that all the values recorded from vegetable were above WHO/FAO Maximum Residue Levels and NESREA this is in line with works of (Njoku et al. 2017) who investigated pesticide residue levels in the two vegetables (*T. occidentalis* and *Celosia argentea* commonly eaten in Lagos state Nigeria, (Bamigboye et al. 2017) that determined the residues of some pesticides in fruits and vegetables (oranges, cucumber, jute leaf, bitter laf, banana, African spinach and fluted pumpkin leaf) purchased from four markets in Ibadan Nigeria and (Dada et al. 2019) in evaluation of organochlorine pesticide residue concentration in salad vegetables (spring onion, spinach and lettuce) and soil samples from three farms in Lagos Nigeria. All these findings recorded concentrations above the MRLs.

The concentration was also ranked by occurrence for vegetable by Area Councils Abaji ranked 1st in Alpha-BHC, Endrin, Endosulfan Sulfate and the only Area Council that Aldrin was detected this was followed closely by Gwagwalada which ranked 1st in DDT, Gamma-BHC and Beta-BHC. Kwali ranked 1st in Heptachlor and other Area Councils ranked in no particular trend this is an indication that different Area Councils have different pesticide used for the same plant, the concentrations recorded in the vegetable is far higher than the recommended level this is an indication of indiscriminate use of pesticides in these Area Councils particularly those detected for which the Area Councils ranked first.

The result obtained from this research shows that a lot of farmers around this area depend on these pesticides to protect their crops from pest however, most of these pesticides are persistent in nature and can bioaccumulate along the food chain which may result/pose a health risk to consumers.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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