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ASSESSMENT OF PESTICIDES AND POLYCYCLIC AROMATIC HYDROCARBONS IN BEEF JERKY MEAT FROM NIGERIA AND THEIR DIETARY CONCENTRATION TO HUMAN

Emmanuel Ilesanmi Adeyeye[1*], Olayinka Abidemi Ibigbami[1], Abiodun Folasade Akinsola[1], Olubunmi Adenike Akinwumi[1], Rauf Abioye Olatoye[1], Adeolu Jonathan Adesina[1], Abdul Ademola Olaleye[2]

[1]Department of Chemistry, Ekiti State University, PMB 5363 Ado-Ekiti, Nigeria
[2]Department of Chemistry, Federal University Dutse, Jigawa State, Nigeria
[*]corresponding author: adeyeyeilesanmi2012@gmail.com

ABSTRACT

The study reports the concentrations, daily intake levels and possible potential health risks of 33 pesticides and 16 polycyclic aromatic hydrocarbons (PAHs) in beef jerky meat samples collected from sellers in Ado-Ekiti, Nigeria. The PAHs concentration (µg/kg) ranged from 0.007 (indeno(1,2,3-cd)pyrene) to 0.516 (acenapthylene), while pesticides (µg/kg) ranged from 0.010(2,4,6-trichlorophenol) to 0.272 (oxamyl). The estimated daily intakes of the pesticides were within the acceptable daily intakes (EDI<<<ADI). The hazard indices were significantly less than 1 (HI << 1) with estimated range of 1.08×10^{-7} (pyriproxyfen) to 1.81×10^{-4} (aldrin). Non carcinogenic equivalent (mg/kg/day) intakes of PAHs from beef jerky consumption ranged from 0.000027 (pyrene) to 0.00421 (anthracene), while the carcinogenic equivalent concentration ranged from 0.000024 (chrysene) to 0.265 benzo(a)pyrene. The risk associated with beef jerky meat showed no potential non-carcinogenic and carcinogenic risk while mutagenic and carcinogenic risk revealed low potential health risk as compared to the guideline value (1.0×10^{-6}) for potential cancer risk.

Key words: beef jerky meat, risk assessment, pesticides, polycyclic aromatic hydrocarbons, carcinogenic.

INTRODUCTION

Meat is one of the most important, nutritious and favoured item usually available to the people where it aids at fulfilling most of their body needs. Meat is an important constituent of a balanced diet. Meat is high in protein, moderate in fat, low in carbohydrates and good source of minerals and vitamins (Ahmad et al., 2018).

Kilishi (kilichi) is a version of jerky meat that is highly cherished and consumed in Hausaland (Nigeria). It is a form of suya usually made from deboned cow, sheep or goat meat. In preparing kilishi, each of the selected muscle is skinned into sheets of about one meter or less for quick drying. Dried sheets of meat are then collected and kept for next process (Adeyeye *et al.*, 2020. [Jerky is lean trimmed meat that has been cut into strips and dried to prevent spoilage.] This drying includes the addition of salt to prevent bacteria growth before the meat has finished the drying process (Adeyeye *et al.*, 2020). To add sweetener to kilishi, a paste is made from peanuts, called labu, diluted with adequate water, spices, salt, ground onions, and sometimes sweetness such as honey. Date palm may also be added as a sweetener. The dried "sheets" of meat are then immersed

one after the other in the labu paste to coat them, before being left to dry for hours before roasting to taste (Nigeria Today, 2016; Nigeria, Kano-kilishi, 2016). Kilishi is a snack with low fat because fat is removed during preparation and the fat that remained mostly dripped off during drying.

Cattle from whose muscle the jerky meat is usually collected are ruminant animals. They move about in the bush to get their plant food. In this course, it is possible that they consume plants already laced with various forms of pesticides. Also, during kilishi preparation, the muscle is usually dried (through smoking) and finally roasted. Authors of this article felt that in the process of eating various plant materials, the cattle could feed on plants laced with pesticides. also in drying process, the kilishi could have been contaminated by smoke. It is on the basis of this that the authors, decided to determine simultaneously the content of pesticides and polycyclic aromatic hydrocarbons that could have been present in the sample of kilishi. The obtained data are going to be then used to give nutritional advice on the consumption of kilishi. In the analysis of kilishi sample, the following principles were followed in the various determinations. PAHs were determined using the procedure of ASTM (1978, 1979) whilst the pesticides were determined following solid-liquid extraction with florisil clean up method. The reasons for using these methods had been earlier explained in this section.

MATERIALS AND METHODS

Sampling

The samples (beef jerky meat) were bought from the sellers in October, 2018 in Ado-Ekiti. Four samples were bought, blended, pulverized and homogenized into a composite sample and kept in a cool dry place prior to extraction and analyses.

Extraction and clean-up procedure of the samples for PAHs analysis

The extraction method for the analysis of polycyclic aromatic hydrocarbon profiles in the samples was by employing the modified methods of American Society for Test Materials (ASTM) D3328 (1978) and ASTM 3415 (1979). Fifty grams of each sample was carefully taken and emptied into a 27 mL capacity McCartney bottle of borosilicate material and 10 mL of the ratio 3:1 (v/v) n-hexane: dichloromethane was added. The bottle and its content were placed in the sonicator to extract the hydrocarbons for about 2 hours. The organic layer was filtered using Whatman No 2 filter paper into 250 mL capacity borosilicate beaker.

The concentrated extract was separated into the aliphatic profile and polyaromatic hydrocarbons profiles by packing the glass column with activated alumina, neutral and activity grade 1. 10 mL of the treated alumina was packed into the column and cleaned properly with n-hexane. The extract was transferred onto the alumina and was allowed to run with the aid of the n-hexane to remove the aliphatic profiles into the pre-cleaned 20 mL capacity glass container. The mixture was concentrated to 1.0 mL by stream of nitrogen gas before the gas chromatography analysis.

Extraction and clean-up procedure of the samples for pesticides analysis

Twenty grams of fresh and dried homogenized samples were each placed in a glass container with 20 g of anhydrous Na_2SO_4 and mixed with 100 mL of a 1:1 mixture of n-hexane and acetone (v/*v*) and 20 mL of methanol. Solid-liquid extraction was performed on a magnetic stirrer for 2 hours at room temperature. After the extraction, the emulsion was transferred into cuvettes and put in an ultracentrifuge for 10 minutes at 3000 cycles per minute, for the separation of the three phases (organic, aqueous and solid). The organic extract was pipetted and water contained in it was

removed by transferring it through a layer of anhydrous sodium sulphate. The sulphur present in the sample was removed with an activated elementary powder (copper fine powder GR particle size 63 µm) and cyclohexane on a magnetic stirrer for 10 minutes. The cyclohexane extract was purified using a Florisil column.

A 30 cm glass stoppered column was filled with 6 g activated florisil (60- 100 mesh) and topped with 2 g of anhydrous sodium sulphate. The sample extract was transferred to the Florisil column which was already saturated with n-hexane. The column was eluted with 200 ml eluent (50 % methylene chloride + 1.5 % acetonitrile + 48.5 % n-hexane) at the rate of 5 mL/min. The collected eluent was concentrated on rotary evaporator at 40 ^{o} C and dissolved in 2 mL of ethyl acetate for pesticides analysis.

Gas chromatographic condition for PAHs

The gas chromatography conditions for the analysis of PAHs were as follows: GC model: HP6890 powered with HP ChemStation Rev. A 09.01[1206]. The carrier gas flow rate was 2.0 mL/min; injector temperature: Split injection: 20:1; carrier gas: nitrogen; inlet temperature: 250 ^{o}C. Column type: HP-1; column characteristics: (30 m x 0.25 mm x 0.25 µm); oven programme: initial temperature at 60 ^{o}C for 5 minutes, first ramping 15 ^{o}C/min for 14 min, maintained for 3 min, second ramping at 10 ^{o}C/min for 5 min, maintained for 4 min; detector: flame ionization detector (FID); detector temperature: 320 ^{o}C; hydrogen pressure: 28 psi; nitrogen column air: 30 psi; compressed air: 32 psi. The total run time was 31 minutes.

Gas chromatographic condition for pesticides

The gas chromatographic conditions for the pesticides were as follows: GC model: HP6890 powered with HP ChemStation Rev. A 09.01[1206]; the carrier gas flow rate was 1.0 mL/min; injector temperature: split injection: 20:1; carrier gas: hydrogen; inlet temperature: 250 ^{o}C; column type: HP 5MS ; column characteristics: (10 m x 0.25 mm x 0.2 µm); oven programme: initial temperature at 110 ^{o}C for 5 minutes, first ramping 27 ^{o}C/min for 14 min; maintained for 3 min; second ramping at 10 ^{o}C/min for 5 min; maintained for 4 min; detector: pulsed flame ionization detector (PFPD); detector temperature: 320 ^{o}C; hydrogen pressure: 20 psi; nitrogen column air: 20 psi; compressed air: 35 psi. The total run time was 31 minutes.

Health risk estimation for pesticides

For the pesticides, the health risk estimation was formed on the levels of pesticides in the beef jerky meat and daily meat consumption rate in Nigeria. The estimated daily intake (EDI) was calculated as per international guidelines (FAO/WHO, 2002) using the equation:

$$EDI = C \times M/W \quad (1)$$

Where C is the concentration of individual pesticides (µg/kg), M is meat consumption rate per person (kg/day). The meat consumption rate for an adult was calculated using 23 g (0.023 kg/person) (knoema.com); while W is average body weight of an adult (70 kg).

Health risk estimation for PAHs

Benzo(a)pyrene equivalent estimation

In determining the carcinogenic risk from exposure to PAHs in the beef jerkey meat, the United State Environmental Protection Agency [USEPA] guideline, as described by Cheung et al. (2007) was employed. In this method, benzo(a)pyrene is used as a marker for the occurrence and effect of

carcinogenic PAHs in food. The overall carcinogenic health risk from the measured PAHs was estimated based on toxic equivalent factors (TEFs) derived from the cancer potencies of individual PAH compounds relative to the cancer potency of benzo(a)pyrene (Nyarkoet al., 2011). Table 1 shows the toxic equivalent factor (TEF) and mutagenic equivalent factor (MEF) values (Nisbet&LaGoy, 1992; Durant et al., 1996, 1999) for each PAH.

Table 1. Proposed benzo(a)pyrene equivalent factors for carcinogenic (TEF) and mutagenic toxicity (MEF)

PAHs	TEF	MEF
Naphthalene	0.001	
Acenaphthylene	0.001	
Acenapthene	0.001	
Fluorene	0.001	
Phenanthrene	0.001	
Anthracene	0.01	
Fluoranthene	0.001	
Pyrene	0.001	
Benzo(a)anthracene	0.1	0.082
Chrysene	0.001	0.017
Benzo(b)fluoranthene	0.1	0.25
Benzo(k)fluoranthene	0.01	0.11
Benzo(a)pyrene	1.0	1.0
Indeno(1.2.3-cd)pyrene	1.0	0.29
Dibenzo(a,h)anthracene	0.1	0.31
Benzo(g,h,i)perylene	0.01	

TEF (Nisbet and LaGoy, 1992); MEF (Durant *et al.*, 1996, 1999)

The benzo(a)pyrene equivalent concentrations TEQ_{Bap} is the sum of product of each individual PAH and its TEF (AFSSA, 2003). The mutagenicity of individual PAH relative to BaP had also been computed using the mutagenic equivalent factor (MEF) proposed by Durantet al. (1996, 1999). The sum of the concentration of each individual PAH multiplied by the corresponding MEF gives the mutagenic equivalent (MEQ).

$$TEQ_{Bap} = \sum(TEF_i \text{ x } C_i) \qquad (2)$$

$$MEQ_{Bap} = \sum(MEF_i \text{ x } C_i) \qquad (3)$$

Where C_i is the measured individual PAH concentration for the (i^{th}) compound with the assigned TEF_i or MEF_i.

Dietary exposure to PAHs

Human dietary exposure doses express as (mg/kgBW/day) occurring over a lifetime was determined.

$$\text{Average daily dose} = \frac{\text{TEQ or MEQ x IR x CF}}{\text{BW}} \qquad (4)$$

where IR is the ingestion or intake rate of carcinogenic (mutagenic) PAHs based on average meat consumption rate set at 23g/day/person, CF is the conversion factor (0.001 mg/kg) and BW is the body weight which is set at 70 kg

Non-cancer hazard, carcinogenic and mutagenic risk calculations

The risk associated with the dietary exposure to non-carcinogenic PAHs was evaluated using hazard quotient approach (USEPA, 2000). Hazard quotient represents a ratio of the exposure dose for each PAH divided by reference dose (RfD).

$$\text{Hazard quotient (HQ)} = \frac{\text{Average daily dose (ADD)}}{\text{Reference Dose (RfD)}} \qquad (5)$$

The reference doses for non-carcinogenic PAHs and proposed equivalent factors for carcinogenic (TEF) and mutagenic toxicity (MEF) are shown in Table 2. Summation of individual hazard quotients results gives the hazard index.

$$\text{Hazard Index (HI)} = \sum(\text{HQ}_1 + \text{HQ}_2 + \cdots \text{HQ}_\text{n}) \qquad (6)$$

The calculated TEQ_{Bap} and MEQ_{Bap} for the seven United States Environmental Protection Agency (USEPA) classified carcinogens (mutagens) were used to estimate carcinogenic and mutagenic risk involved in consumption of jerky meat for a life time of 70 years (USEPA, 2000).

Table 2. The reference doses for non-carcinogenic PAHs and proposed benzo(a)pyrene equivalent factors for carcinogenic (TEF) and mutagenic toxicity (MEF)

PAHs	RfD (mg/kg/day)		CSF (mg/kg/day)
Naphthalene	2.00×10^{-2}	Benzo(a)anthracene	7.30×10^{-1}
Acenaphthylene	2.00×10^{-2}	Chrysene	7.30×10^{-3}
Acenapthene	6.00×10^{-2}	Benzo(b)fluoranthene	7.30×10^{-1}
Fluorene	4.00×10^{-2}	Benzo(k)fluoranthene	7.30×10^{-2}
Phenanthrene	-	Benzo(a)pyrene	7.30
Anthracene	3.00×10^{-2}	Indeno(1.2.3-cd)pyrene	7.30×10^{-1}
Fluoranthene	4.00×10^{-2}	Dibenzo(a,h)anthracene	7.30
Pyrene	3.00×10^{-2}		
Benzo(g,h,i)perylene	4.00×10^{-2}		

CSF (USEPA, 2004)

The total risk due to exposure to mixtures of carcinogenic (or mutagenic) PAHs is the product of the dietary carcinogen exposure dose (mg/kg BW/day) and benzo(a)pyrene slope factor (USEPA, 2004) value as shown in Table 2.

$$\text{Risk (carcinogenic or mutagenic)} = \text{Average daily dose x slope factor} \qquad (7)$$

RESULTS AND DISCUSSION

Thirty-three pesticides (insecticides and herbicides) of different classes or groups were observed from the collected samples. The class included organochlorine (7), organophosphorus (6), pyrethroids (4), carbamate (3), phenoxy group (3), urea (3), hydrocarbon (3) and others (5). The pesticides concentration generally ranged from 0.010 µg/kg (2,4,6-trichlorophenol) to 0.272 µg/kg (oxamyl). The organochlorine pesticides were in the order: endosulfan> methoxychlor > pentachlorophenol > metolachlor > alachlor > aldrin > dieldrin. The organophosphate showed that dichlorvos > pirimiphos-methyl > phosphamidon> chlorpyrifos > fenithrothion > malathion. Pyrethroids were in the order of fenvalerate > cypermethrin > permethrin > deltamethrine. Carbamate reflected that oxamyl > carbofuran > carbendazin. Phenoxy group was in the order of dichloroprop > fenoprop > 2,4-D. Urea showed that chlorotoluron > isoproturon. Hydrocarbons; cyanazine > atrazine > simazine, while for others we have: bromoethane, pendimethalin > pyriproxyfen > phosphine > 2,4,6- trichlorophenol. The concentrations of the pesticides in the beef jerky meat were presented in Table 3.

Table 3. Concentration ((µg/kg) of pesticides in the beef jerky meat (kilishi)

	Class of pesticides	Concentration		Class of pesticides	Concentration
Pentachlorophenol	OC	0.091	Carbendazim	CB	0.101
Alachlor	OC	0.079	Oxamyl	CB	0.272
Metolachlor	OC	0.083	Carbofuran	CB	0.116
Endosulfan	OC	0.157	2,4-D	PO	0.040
Methoxychlor	OC	0.128	Dichloroprop	PO	0.111
Aldrin	OC	0.055	Fenoprop	PO	0.102
Dieldrin	OC	0.044	Phosphine	OT	0.029
Dichlorvos	OP	0.168	Bromoethane	BR	0.163
Fenithrothion	OP	0.100	Pendimethalin		0.087
Phosphamidon	OP	0.117	Pyriproxyfen		0.033
Pirimiphos-methyl	OP	0.142	2,4,6-Trichlorophenol		0.010
Malathion	OP	0.066	Isoproturon	UR	0.057
Chlorpyrifos	OP	0.107	Chlorofoluron	UR	0.162
Cypermethrin	PY	0.140	Cyanazine	HC	0.148
Fenvalerate	PY	0.159	Atrazine	HC	0.074
Permethrin	PY	0.048	Simazine	HC	0.073
Deltamethrine	PY	0.036			

OC = Organochlorine; OP = Organophosphorus; PY = Pyrethroid; CB = Carbamate; PO = Phenoxy; OT= Organotin; BR = Organobromine; UR =Urea; HC = Heterocyclic.

Health risk assessment of pesticides in the beef jerky meat

To determine the potential human health risk of pesticides in the beef jerkey meat, estimated daily intake and hazard indices were calculated (Table 4).

Table 4. Estimated dose values and hazard indices of pesticides in the beef jerky meat (kilishi)

	WHO/IPCS (2009) ADI (µg/kg/day)	EDI (µg/kg/day)	Hazard index
Pentachlorophenol	-	2.99×10^{-5}	-
Alachlor	-	2.60×10^{-5}	-
Metolachlor	-	2.73×10^{-5}	-
Endosulfan	-	5.16×10^{-5}	-
Methoxychlor	100	4.21×10^{-5}	4.21×10^{-7}
Aldrin	0.1	1.81×10^{-5}	1.81×10^{-4}
Dieldrin	0.1	1.45×10^{-5}	1.45×10^{-4}
Dichlorvos	4	5.52×10^{-5}	1.38×10^{-5}
Fenithrothion	6	3.29×10^{-5}	5.48×10^{-6}
Phosphamidon	10	3.84×10^{-5}	3.84×10^{-6}
Pirimiphos-methyl	30	4.67×10^{-5}	1.56×10^{-6}
Malathion	20	2.17×10^{-5}	1.09×10^{-6}
Chlorpyrifos	10	3.52×10^{-5}	3.52×10^{-6}
Cypermethrin	20	4.60×10^{-5}	2.30×10^{-6}
Fenvalerate	20	5.22×10^{-5}	2.61×10^{-6}
Permethrin	50	1.58×10^{-5}	3.16×10^{-7}
Deltamethrine	10	1.18×10^{-5}	1.18×10^{-6}
Carbendazim	30	3.32×10^{-5}	1.11×10^{-6}
Oxamyl	9	8.94×10^{-5}	9.93×10^{-6}
Carbofuran	1	3.81×10^{-5}	3.81×10^{-5}
2,4-D	10	1.31×10^{-5}	1.31×10^{-6}
Dichloroprop	-	3.65×10^{-5}	-
Fenoprop	-	3.35×10^{-5}	-
Phosphine	-	9.53×10^{-6}	-
Bromoethane	-	5.36×10^{-5}	-
Pendimethalin	-	2.86×10^{-5}	-
Pyriproxyfen	100	1.08×10^{-5}	1.08×10^{-7}
2,4,6-Trichlorophenol	-	3.29×10^{-6}	-
Isoproturon	-	1.87×10^{-5}	-
Chlorofoluron	-	5.32×10^{-5}	-
Cyanazine	-	4.86×10^{-5}	-
Atrazine	20	2.43×10^{-5}	1.22×10^{-6}
Simazine	-	2.40×10^{-5}	-

The estimated daily intakes of the pesticides ranged from 3.29×10^{-6} (2,4,6-trichlorophenol) to 8.94×10^{-5} (oxamyl). These were within the acceptable daily intakes (i.e all the calculated EDI <<< ADI

(WHO/IPCS, 2009). An aggregate daily exposure to a pesticide residue at or below the reference dose is generally considered to be safe levels of exposure overtime. For hazard index (HI), the HI ranged from 1.08 x 10^{-7}(pyriproxyfen) to 1.81 x 10^{-4} (aldrin). The HI were significantly less than 1 (H<<1). For cases where HI < 1, the pesticides involved were unlikely to cause harm to consumers and where hazard index (HI) is greater than 1 (HI > 1), the pesticides had exceeded the maximum acceptable level and may cause harm to humans (Tsakiriset al., 2011). Hence, the calculated HI from this study showed no potential human hazard or risk to human health.

Table 5 showed the PAHs concentration in the beef jerky meat samples. The PAHs concentration ranged from 0.007 µg/kg (indeno(1,2,3-cd)pyrene) to 0.516 µg/kg (acenapthylene). The sum of non-carcinogenic PAHs was 2.10 µg/kg, while the seven carcinogenic PAHs showed values of 0.44 µg/kg. The sum of low molecular weight PAHs was 2.01 µg/kg, while the high molecular weight PAHs showed 0.525 µg/kg.

Table 5. Concentration (µg/kg) of PAHs in the beef jerky meat

PAHs	Concentration	PAHs	Concentration
Naphthalene^{+}	0.357	Benzo(k)fuoranthene**	0.039
Acenaphthylene^{+}	0.134	Benzo(a)pyrene**	0.265
Acenaphthene^{+}	0.516	Indeno(1,2,3-cd)pyrene**	0.007
Fluorene^{+}	0.409	Dibenzo(a,h)anthracene**	0.077
Phenanthrene^{+}	0.122	Benzo(g,h,i)perylene*	0.024
Anthracene^{+}	0.421	TPAHs	2.53
Fluoranthene*	0.085	∑7C-PAHS	0.440
Pyrene*	0.027	∑NC-PAHS	2.10
Benzo(a) anthracene**	0.011	∑LMW	2.01
Chrysene**	0.024	∑HMW	0.525
Benzo(b)fluoranthene**	0.017		

$^{+}$indicates PAHs classified as low molecular weight PAHs; * high molecular weight and non-carcinogenic PAHs; **high molecular weight and carcinogenic PAHs; ∑**7C**-PAHs= sum of seven carcinogenic PAHs, ∑nc-PAHs= sum of non-carcinogenic PAHs; ∑LMW-PAHs= sum of low molecular weight PAHs; ∑HMW-PAHs= sum of high molecular weight PAHs

Akpambang et al. (2009) determined polycyclic aromatic hydrocarbons in commonly consumed Nigerian smoked/grilled fish and meat using traditional systems, which used a wood fire, were heavily contaminated with benzo(a)pyrene at levels ranging from 2.4 to 31.2 µg/kg. Duke and Albert (2007) found benzo(a)pyrene contents ranging from 6.5 to 21.5 µg/kg in suya meat. This range was considerably higher than what was reported for benzo(a)pyrene in this study. The results obtained from this present study were completely lower in most cases with what was reported by Moretet al. (1999), Storelliet al. (2003), Watson et al. (2004), Yurchenco& Molder, (2005) and Duedahl-Olesenet al. (2006) in fish and meat from European markets. Berbecued samples showed marked differences in PAHs concentration than fried, grilled and roasted samples. Aaslyngetal. (2013) reported 17.3, 1.1 and 2.6 µg/kg in homemade barbecued beef, chicken and pork, while Nishaet al. (2015) reported that PAHs concentration in pizza baked in wood-burning oven were higher than barbecued pork and beef. Ogbuagu and Ayoade (2012) reported PAHs level in some Nigerian staple foods (roasted plantain, suya and roasted fish). A combined PAHs of 46.5,

37.2 and 3.5 µg/kg were reported. An average concentration of 3.38 reported for suya by Ogbuagu and Ayoade (2012) was comparatively lower than what was reported in this study.

Health risk assessment of PAHs in the beef jerky meat

Non-carcinogenic

To assess the non-carcinogenic risk of PAHs associated with the sampled beef jerky meat, the non-carcinogenic equivalent, average daily intake and hazard index were calculated (Table 6). The benzo(a)pyrene equivalent concentration ranged from 0.000027 (pyrene) to 0.00421 (anthracene) mg/kg/day.

Table 6. Risk assessment based on non-carcinogenic equivalent, average daily dose and hazard index of the beef jerky meat

Non carcinogenic	mg/kg/day
Naphthalene	0.000357
Acenaphthylene	0.000134
Acenapthene	0.000516
Fluorene	0.000409
Phenanthrene	0.000122
Anthracene	0.00421
Fluoranthene	0.000085
Pyrene	0.000027
Benzo(g,h,i)perylene	0.00024
∑BaP TEQ	0.0061
BaP TEQ daily dose (mg/kg/day)	1.18×10^{-5}
Hazard Index	1.97×10^{-4}

The sum of benzo(a)pyrene equivalent concentration was 0.0061 mg/kg/day. The average daily intake of non-carcinogenic PAHs was 1.18 x 10^{-5} mg/kg/day. The hazard index of the non-carcinogenic PAHs through consumption was 1.97 x 10^{-4}. Therefore, an HI < 1 was obtained in the present study. According to EPA standard, when HI exceeds 1, it has an adverse human health effect. The study thus suggested that the PAHs level in the beef jerky meat posed no potential non-carcinogenic health risk to human being.

Carcinogenic and Mutagenic risk

The carcinogenic and mutagenic risk assessments of the beef jerky meat were shown in Tables 7 and 8. The carcinogenic toxicity (TEQ_{Bap}) and mutagenic toxicity (MEQ_{Bap}) relative to benzo(a)pyrene were calculated for the carcinogenic and mutagenic risk assessments. The TEQ for the carcinogenic PAHs was 0.204, while the mutagenic equivalent was 0.2995. The equivalent average daily dose (mg/kg/day) carcinogenic was 9.32 x 10^{-5}, while the mutagenic average daily dose was 9.84 x 10^{-5}.

Table 7. Risk assessment based on carcinogenic equivalent, average daily dose and the risk associated with the beef jerky meat

Carcinogenic	mg/kg/day
Benzo(a)anthracene	0.0027
Benzo(b)fluoranthene	0.0017
Benzo(k)fluoranthene	0.00039
Benzo(a)pyrene	0.265
Dibenzo(a,h)anthracene	0.0077
Chrysene	0.000024
Indo(1,2,3-cd)pyrene	0.007
∑BaP TEQ	0.204
BaP TEQ daily dose (mg/kg/day)	9.32×10^{-5}
LECR	6.57×10^{-4}

LECR= life time excess carcinogenic risk

Table 8. Risk assessment based on mutagenic equivalent, average daily dose and risk associated with the beef jerky meat

Carcinogenic	mg/kg/day
Benzo(a)anthracene	0.000902
Benzo(b)fluoranthene	0.003
Benzo(k)fluoranthene	0.00429
Benzo(a)pyrene	0.265
Dibenzo(a,h)anthracene	0.02387
Chrysene	0.000408
Indo(1,2,3-cd)pyrene	0.00203
∑BaP TEQ	0.2995
BaP MEQ daily dose (mg/kg/day)	9.84×10^{-5}
LECR	6.94×10^{-4}

LECR= life time excess carcinogenic risk

The results obtained with this study showed that the consumption of the beef jarkey meat posed little potential carcinogenic and mutagenic risk to human since the carcinogenic and mutagenic calculated values were a bit higher than the USEPA (1993, 2009) unit risk of 1.0×10^{-5} mg/kg/day.

CONCLUSION

The study showed low contamination of the beef jerky meat with the studied PAHs and pesticides. This study was carried out using the principles as enunciated in the various determinations: polyaromatic hydrocarbons were determined using the procudures of ASTM for the years 1978 and 1979 whereas pesticides were determined following the process of solid-liquid extraction method with flotisil clean up. The results showed that indeno(1,2,3-cd)pyrene and 2,4,6-trichlorophenol as the least, while acenapthylene and oxamyl as the highest PAHs and pesticides concentration in the sample. The estimated daily intakes (EDI) for pesticides were generally below available daily intake (ADI). The study showed that the consumers were not at risk due to pesticides residues. PAHs levels suggested that the amount might pose no potential non-carcinogenic effects

on humans, while the carcinogenic indicated low or minimum risk to human health. The study therefore, recommended that cows should be discouraged from grazing from pesticides contaminated area or farm. Effective measures should also be adopted to reduce or stop the deleterious contribution of pesticides to farm or grazing areas. There is also the need for an intense awareness among beef jerky meat sellers on reasons why modern smoking or processing technique should be adopted as the local or traditional (charcoal) increases/introduce more PAHs to food.

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