Asian Food Science Journal

Volume 22, Issue 3, Page 1-10, 2023; Article no.AFSJ.97585
ISSN: 2581-7752

Assessment and Characterization of Residual Concentrations from Some Cook-in Food Packages Utilized in Nigeria – '*Moi-Moi'*: A Case Study

Iguh, Blessing Ngozi [a*], Bede, Evelyn Njideka [a] and Akanbi, Magdalene Nkeiru [b]

[a] *Department of Food Science and Technology, Federal University of Technology, Owerri, Nigeria.*
[b] *Department of Polymer, Federal University of Technology, Owerri, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. This Thesis was carried out and written by author IBN. Author BEN was the supervisor and author AMN played the role of a co-supervisor. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2023/v22i3621

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/97585

Original Research Article

Received: 08/01/2023
Accepted: 14/03/2023
Published: 20/03/2023

ABSTRACT

Aim: To assess the magnitude and safety of migrants from three cook-in food packaging materials (plantain leaf, polyethylene film and aluminium foil) into cooked *'moi-moi'*.
Methodology: The *'moi-moi'* was prepared, packaged in three different packaging materials and cooked to doneness. Analyses of possible migrants from the packaging materials were carried out using standard methods. Raw *'moi-moi'* paste and cooked *'moi-moi*' samples were analysed for migrants from associated packaging material on day zero and day 3 of frozen storage. Proximate composition and sensory evaluation as affected by the packaging materials were also conducted. Data obtained were analyzed using two-way analysis of variance (ANOVA) and the means separated by Duncan's New Multiple Range Test (DNMRT).

**Corresponding author: Email: iguhblessing29@yahoo.com, iguh.blessing@mouau.edu.ng;*

Results: Results obtained showed that the heavy metals originally present in the aluminium foil and plantain leaf gained entrance into the cooked '*moi-moi*' and the same was the pesticide residue from the plantain leaf. Phthalates and some volatile organic compounds were found to migrate from polyethylene film into the cooked *'moi-moi'*. The proximate compositions showed that the *'moi-moi'* cooked in plantain leaf had the highest value in ash (9.14%), fibre (3.95%) and protein (21.41%) followed by that in aluminium foil with 6.47% in ash and 1.34% in fibre. The sensory results showed no significant differences in taste, after taste perception, mouthfeel and general acceptability among the *'moi-moi'* samples cooked in the different packaging materials on day O (the day *'moi-moi'* was cooked). Nonetheless, on day 3 (3 days frozen storage), significant differences in appearance, mouthfeel, aroma, and general acceptability of the *'moi-moi'* samples existed except in after taste perception.

Conclusion: The concentrations of all the migrants were found to increase with increase in contact time but were all below the safety limits stipulated by WHO, Codex Alimentarius and JECFA even on day 3 of frozen storage.

Keywords: Packaging materials; migrants; 'moi-moi'; cook-in packaging.

1. INTRODUCTION

Researches have shown that components of food packaging materials such as the unreacted monomers, additives and other components of the food packaging material can migrate into the packaged foods [1,2,3]. These components if present in foods above their maximum limits can pose a lot of health risks to consumers [4,5]. Examples of these components are heavy metals (lead, cadmium, nickel and arsenic) which have public health concern due to their adverse effects on human health and researches have shown that human exposures to these heavy metals occur mainly through food, water and inhalation [6,7].

Among all food packaging materials, polymeric food packages have been implicated to pose the highest risk of toxic migrants into packaged foods [8,9,10]. Notwithstanding, this still forms the major cook-in packaging film used in Nigeria and most African countries. Because of safety concern however, some people opt for aluminium film and plant leaves for such food preparations such as *'moi-moi'*, *Okpa, Elele oka* and *Epiti*. Of all the foods cooked in films, *'moi-moi'* is the most commonly consumed. *'Moi-moi'* is a ready-to-eat pudding prepared by steaming a mixture of wet milled beans (or beans flour and water) and other ingredients (pepper, onions, salt, fish etc) wrapped in polyethylene film, aluminium foil or leaves. It is consumed by people of all ages and socio-economic strata and due to its popularity and large consumer acceptance, *'moi-moi'* is no longer just limited to the category of street foods but has made its way up to the menu of all classes of Nigerian restaurants [11].

In this study, the assessment and characterization of migrants from three packaging films (polyethylene film, aluminium foil and plantain leaves) mostly used in the preparation of *'moi-moi'* in Nigeria was investigated. The study covered the level of migrations from these packaging films during cooking, cold storage and reheating of the food after cold storage.

2. MATERIALS AND METHODS

2.1 Preparation of *'moi-moi'*

A modified method of Beleya and Eke-Ejiofor [11] was adopted for the preparation of the *'moi-moi'*. 300g of beans flour was mixed with 531ml of warm water, rested for 15 minutes after which other ingredients (30g dry pepper, 60g chopped fresh onions, 2g seasoning spice and 140ml of groundnut oil) were added and mixed to form the raw *'moi-moi'* paste. The paste was then packaged in each of the three packaging materials and steamed for 45 minutes and then cooled to room temperature.

2.2 Analyses Carried Out

Analyses were carried out on the unused packaging films, on the raw *'moi-moi'* paste and on the *'moi-moi'* samples cooked in the different films. The analyses on the cooked *'moi-moi*' samples were carried out on day zero (the day the *'moi-moi'* were cooked) and on the 3rd day (3 days storage in the freezer).

2.2.1 Analyses on the unused packaging films

The unused packaging films (aluminum foil, polyethylene film and plantain leaf) were analyzed for associated possible migrants. The aluminum foil was analyzed for heavy metals (lead, cadmium, aluminum, nickel, arsenic) using Agilent FS240AA Atomic Absorption

A: *'moi-moi'* Cooked in Aluminium Foil

B: *'moi-moi'* Cooked in Transparent Polymer Film

C: *'moi-moi'* Cooked in Plantain Leaf

Plate 1. *'Moi-moi'* Cooked in Aluminium Foil, Transparent Polymer Film and Plantain Leaf

Spectrophotometer according to the method of APHA [12]. The polyethylene was analysed for phthalates and volatile organic compounds using Gas Chromatography as described by AOAC [13] while the plantain leaf was analysed for heavy metal (lead, cadmium, aluminium, nickel and arsenic) and pesticide residue compounds as described by AOAC [13].

2.2.2 Analyses on the raw 'moi-moi' paste and cooked 'moi-moi' samples

The raw *'moi-moi'* paste was analysed for presence of heavy metals (lead, cadmium. Aluminium, nickel, arsenic), phthalates, volatile organic compounds and pesticide residue while the *'moi-moi'* samples were analysed based on the associated migrants from the respective packaging material in which they were cooked in. Proximate composition and sensory evaluation were also carried out on the cooked *'moi-moi'* samples as described by Onwuka [14] and Bede et al. [15]. A total of 25 semi-trained panellist was used to assess the appearance, taste, after taste perception, aroma and mouthfeel of the cooked *'moi-moi'* samples using a 9-point Hedonic scale as described by Iwe [16] with 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely.

2.3 Statistical Analysis

Data obtained were analyzed using a two-way analysis of variance (ANOVA) and the means separated by Duncan's New Multiple Range Test (DNMRT) using the Statistical Package for Social Sciences (SPSS) version 16 at 5% ($P<0.05$) acceptable level.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

The results of the proximate analysis are presented in Table 1. The *moi*sture contents of the *'moi-moi'* samples cooked in the different packaging films were 10.977%, 14.697% and 19.911% for samples cooked in polyethylene film, aluminium film and plantain leaf respectively. All the samples showed a decrease in *moi*sture content when compared with the raw paste (41.545%). This could be attributed to protein denaturation during the cooking of the *'moi-moi'* samples. The percentage *moi*sture contents of all the *'moi-moi'* samples were lower than those reported by Ezeocha *et al.,* [3] for *'moi-moi'* cooked in leaf (72.11%), nylon (69.53%) and aluminium foil (71.28%) and that (51.20% – 59.60%) reported by Okwunodulu *et al.* [17] for blends of *'moi-moi'* cooked in '*etere*' leaf. The lowest value recorded for sample cooked in polyethylene film could be attributed to low permeability of polyethylene to moisture [18] however, the high *moi*sture contents (10.977 – 19.911%) recorded in this work are good indications of high perishability of the *'moi-moi'* samples [19,20].

The ash contents of the *'moi-moi'* samples ranged from 1.434% - 9.139%, fibre contents from 1.192% - 3.953%, the fat contents from 2.048% -6.267% while the protein contents ranged from 17.694% - 21.414%. All these values were significantly lower than those; ash (4.906%), fibre (9.186%), fat (8.678%) and protein (34.159%) observed in the raw paste. The resultant effects of heat on fibre and protein [21,22] and the varying fat retention capacities of

Table 1. Proximate Composition of Raw *'moi-moi'* Paste and Cooked *'moi-moi'* Samples on Day Zero (Dry matter basis)

Parameters	Raw Paste (%)	CMP_O (%)	CMAL (%)	CMPL (%)	LSD
Moisture	$41.545^a \pm 1.653$	$10.977^d \pm 0.488$	$14.697^c \pm 0.409$	$19.911^b \pm 0.077$	1.669
Ash	$4.906^c \pm 0.271$	$1.434^d \pm 0.045$	$6.468^b \pm 0.181$	$9.139^a \pm 0.160$	0.344
Fibre	$9.186^a \pm 0.221$	$1.192^c \pm 0.064$	$1.338^c \pm 0.109$	$3.953^b \pm 0.099$	0.257
Fat	$8.678^a \pm 0.318$	$2.048^c \pm 0.051$	$7.307^b \pm 1.299$	$6.267^b \pm 0.045$	1.260
Protein	$34.159^a \pm 1.635$	$17.694^c \pm 0.651$	$17.234^c \pm 0.435$	$21.414^b \pm 0.192$	1.718
Carbohydrates	$42.956^d \pm 0.258$	$77.632^a \pm 0.601$	$67.653^b \pm 0.830$	$59.228^c \pm 0.111$	0.100

Where LSD = Least Significant Difference, CMP_0 = Cooked 'moi-moi' from polymer film, CMAL = Cooked 'moi-moi' from Aluminium foil and CMPL = Cooked 'moi-moi' from plantain leaf. Values are Means ± standard deviation of duplicate determinations $^{a-d}$. Means with the same superscripts within the same row are not significantly (p>0.05) different the packaging materials under heat as well as the dissolution of fat containing ingredients in the *'moi-moi'* during cooking may have resulted to the lower and varying values observed in the fibre, fat and protein contents of the *'moi-moi'* samples [17]. *'Moi-moi'* cooked in plantain leaf recorded the highest in ash, fibre and protein and Ezeocha *et al.* [3] reported same for protein content of *'moi-moi'* cooked in leaves. This has been explained to be the resultant effect of the migration of ash, fibre and proteins from the plantain leaf into the *'moi-moi'* during contact time [23,24]. Akujobi and Amadi [25] recorded a significantly lower crude fibre content value ranges (0.74 – 0.81%) for *'moi-moi'* cooked in polymer film.

3.2 Heavy Metals

The lead, cadmium, nickel and arsenic contents of the *'moi-moi'* samples cooked in aluminium film and plantain leaf on day zero and day 3 all fell below the WHO maximum level range (0.01 – 1mg/kg) for Lead in commodity and product, Codex Alimentarius [26] provisional tolerable monthly intake (PTMI) of 25μg/kg for cadmium, the 2.0mg per body weight Tolerable Weekly Intake (TWI) for Aluminium and the maximum limits of 0.01 -0.5mg/kg for Arsenic in food commodities and products.

Comparing the initial values of lead, cadmium, nickel, aluminium and arsenic recorded for the unused aluminium foil (0.009ppm), unused plantain leaf (0.014ppm) and the raw *'moi-moi'* paste (0.003ppm), it could be deduced that some amounts of heavy metals had migrated from the packaging materials into the cooked *'moi-moi'* during the contact time [27,28,29]. However, the range of values for Nickel contents recorded in this study were lower than 0.025mg/l and 0.335mg/l reported by Ezeocha *et al.* [3] for the Nickel contents of *'moi-moi'* cooked in leaves and aluminium foil respectively.

3.3 Phthalates

No diethyl phthalates were detected in the raw paste and the *'moi-moi'* samples on day 3. However, low levels of di-butyl, di-2-ethylhexyl and benzylbutyl phthalates were detected in the raw *'moi-moi'* paste and these slightly increased in the *'moi-moi'* on day 0 and 3. According to Birnbaum and Schug [30] and EFSA [8], phthalates readily migrates from plastics into the food products when exposed to high temperatures due to the absence of a chemical bond to their parent polymers. This is a possible explanation for the increase in phthalate concentration after cooking and on day 3 after thawing and reheating of the frozen stored *'moi-moi'*. Similar findings were recorded by Moreira *et al.* [31] who observed that migration of di-butyl phthalates into foods increased with increase in contact time however, this is contrary to the report by Fierens *et al.* [32] who recorded a significant reduction in benzylbutyl phthalates with cooking.

3.4 Volatile Organic Compounds (VOCs)

Six (6) VOCs (isoprene, toluene, cumene, polyvinyl alcohol, carbontetrachloride, chloroform) were detected in the raw *'moi-moi'* paste and upon cooking, all showed a decrease in concentration at day O. However, polyvinyl alcohol, carbontetrachloride, chloroform and toluene showed increase in their concentrations on day 3 while benzene and myrcene which were not originally in the raw *'moi-moi'* paste were detected in the cooked *'moi-moi'* on day 3 This further underlines the reports that migrations from food packages into the packaged food increases with increase in contact time [1,33,34].

Table 2. Heavy Metal Contents of Unused aluminium film, plantain leaf, Raw *'moi-moi'* Paste and Cooked '*'moi-moi"* Samples on Day O and 3rd Day of Freezer Storage

Heavy Metal	Raw Paste (ppm)	ALF (ppm)	PLF (ppm)	CMAL0 (ppm)	CMAL3 (ppm)	CMPL0 (ppm)	CMPL3 (ppm)
Lead	0.003	0.009	0.014	0.005	0.012	0.000	0.034
Cadmium	0.000	0.003	0.002	0.000	0.006	0.000	0.017
Aluminium	0.005	0.283	0.010	0.009	0.017	0.000	0.012
Nickel	0.005	0.015	0.007	0.002	0.010	0.006	0.016
Arsenic	0.000	0.008	0.012	0.000	0.006	0.004	0.006

Where ALF= Aluminium foil, PLF = Plantain leaf, CMAL = Cooked 'moi-moi' from Aluminium foil and CMPL = Cooked 'moi-moi' from plantain leaf. Values are Means ± standard deviation of duplicate determinations $^{a-d}$. Means with the same superscripts within the same row are not significantly (p>0.05) different

Table 3. Phthalates in Raw *'moi-moi'* Paste and *'moi-moi'* Cooked in Polymer Film at O and 3rd Day of Freezer Storage

Phthalate ug/g	Raw paste (ug/g)	CMP_O0 (ug/g)	CMP_O3 (ug/g)
Di -2 ethylhexyl	0.0056	0.0039	0.0669
Benzylbutyl phthalates	0.0193	0.0346	0.0761
Dibutyl phthalates	0.0157	0.0197	0.0285
Diethyl phthalates	ND	ND	0.0011

Note: $CMP_0 0$ = Cooked 'moi-moi' from polymer film on day 0, $CMP_0 3$= Cooked 'moi-moi' in Polymer film on day 3 and ND = Not Detected.

Table 4. Volatile organic compounds in raw *'moi-moi'* Paste and *'moi-moi'* cooked in polymer film at O and 3rd day of freezer storage

Volatile Organic Compounds ug/g	Raw paste (ug/g)	CMPo0 (ug/g)	CMPo3 (ug/g)
Isoprene	0.0320	0.0234	0.0037
Polyvinyl alcohol	0.1403	0.0796	0.1308
Chloroform	0.0026	0.0012	0.0030
Toluene	0.1776	0.0014	0.0707
Cumene	0.1199	0.0749	0.0019
Carbontetrachloride	0.0164	0.0104	0.0569
Benzene	ND	ND	0.0827
Myrcene	ND	ND	0.1506
Ethylene	ND	ND	ND

Note: $CMP_0 0$ = Cooked 'moi-moi' from polymer film on day 0, $CMP_0 3$= Cooked 'moi-moi' in Polymer film on day 3 and ND = Not Detected.

Isoprene has been listed on the US Hazardous Substance fact sheet [35] as one of the volatile organic compound posing a health risk to humans upon exposure and since it is carcinogenic, there is no maximum limit of exposure.

3.5 Pesticide Residue

The pesticide residues contained in the raw plantain leaf, raw *'moi-moi'* paste and *'moi-moi'* cooked in the plantain leaf are presented in Table 5.

About eight (8) pesticide residue compounds (endosulfan, G-chlordane, glyphosphate, DDVP, aldrin, profenofos, dichlorvos, carbonfuran) were detected in the plantain leaf while seven (isopropylamine, dichloroBiphnyl, HCB, biphenyl, lindane, P' P' DDD, carbonfuran) were detected in the raw '*"moi-moi'*" paste. Aldrin, profenofos and dichlorvos which were not in the raw paste but were originally in the plantain leaf were found in the cooked *'moi-moi'* both on day zero (0) and on the third day (3) indicating good evidence of migration of these compounds from the plantain leaf into the cooked *'moi-moi'* sample. Dichlorvos has been shown to be slightly water soluble, highly volatile and does not easily bind with soil; and its presence on the leaves of plants could be through transport in air and contact with contaminated water [36]. Similarly, chlordane has been reported to be a soil persistent pesticide that migrates from the soil into pant tissues [37]. This explains their possible presence in the plantain. It is worthy to note that chlordane and Aldrin have been listed under the NAFDAC list of banned pesticides in Nigeria [38].

The presence of the seven pesticide residue compounds in the raw *'moi-moi'* paste could be linked to the pesticides used in the farming and storage of the beans and other ingredients used in the preparation of the *'moi-moi'* sample as shown by WHO [39] that Lindane; one of the compounds found in the raw *'moi-moi'* paste (pesticide used in the farm) has the capacity of remaining in the soil for years and therefore, migrates to food crops planted on the contaminated soil.

3.6 Sensory Evaluation

The sensory evaluation results are presented in Table 6.

Table 5. Pesticide Residue Contents of Raw *'moi-moi'* Paste and *'moi-moi'* Cooked in Plantain Leaf on Day O and 3rd Day of Freezer Storage

Component ug/g	PLF	Raw *'moi-moi'* paste	CMPL0	CMPL3
Endosulfan	0.2421	N.D	N.D	N.D
Isopropylamine	N.D	0.1002	0.0775	0.1685
G-Chlordane	0.1110	N.D	N.D	N.D
DichloroBiphnyl	N.D	0.0683	0.1142	0.1949
HCB	N.D	0.0594	0.1727	0.1636
Glyphosphate	0.0329	N.D	N.D	N.D
Aldrin	0.0352	N.D	0.0308	0.0387
Profenofos	0.0218	N.D	0.1493	0.1819
Chlorpyrifos	N.D	N.D	N.D	N.D
Carbofuran	0.0650	0.0287	0.2166	0.2468
Dichlorvos	0.142	N.D	0.1910	0.2232
Biphenyl	N.D	0.0554	0.2159	0.2303
DDVP	0.799	N.D	N.D	N.D
T- nonachlor	N.D	N.D	0.1235	0.3498
Lindane	N.D	0.0051	N.D	N.D
p'p' DDD	N.D	0.0683	N.D	N.D

PLF = Plantain Leaf, CMPL0 = Cooked 'moi-moi' from plantain leaf on day 0, CMPL3 = Cooked 'moi-moi' from plantain leaf on day 3 and N.D = Not detected.

Table 6. Sensory evaluation results of cooked *'moi-moi'* samples

	Appearance	Mouthfeel	Taste	After taste	Aroma	General Acceptability
Day 0						
CMP_0	$8.12^a \pm 1.20$	$7.36^a \pm 1.68$	$7.56^a \pm 1.00$	$7.20^a \pm 1.78$	$7.92^a \pm 1.19$	$8.20^a \pm 1.47$
$CMAL_0$	$8.08^a \pm 0.95$	$7.32^a \pm 1.35$	$7.76^a \pm 1.48$	$6.84^a \pm 1.86$	$6.80^b \pm 1.92$	$7.76^a \pm 1.17$
$CMPL_0$	$7.08^b \pm 1.58$	$7.12^a \pm 1.76$	$7.72^a \pm 1.62$	$7.20^a \pm 1.19$	$7.80^a \pm 1.16$	$7.64^a \pm 1.73$
LSD	**0.72**	**0.91**	**0.79**	**0.92**	**0.82**	**0.83**
Day 3						
CMP_3	$7.32^a \pm 1.03$	$7.20^a \pm 1.08$	$7.56^a \pm 0.77$	$5.96^a \pm 1.24$	$6.76^{ab} \pm 2.01$	$6.64^b \pm 1.91$
$CMAL_3$	$7.44^a \pm 1.36$	$7.28^a \pm 1.43$	$6.64^b \pm 1.38$	$6.72^a \pm 1.75$	$7.64^a \pm 1.22$	$8.00^a \pm 0.96$
$CMPL_3$	$6.36^b \pm 0.70$	$6.08^b \pm 1.94$	$7.32^a \pm 1.63$	$6.20^a \pm 1.78$	$6.32^b \pm 1.65$	$7.68^a \pm 1.18$
LSD	**0.60**	**0.86**	**0.74**	**0.91**	**0.93**	**0.80**

Where: CMP_3= Cooked 'moi-moi' from polymer film (Day 3), $CMAL_3$ = Cooked 'moi-moi' from aluminiuum foil (Day 3), $CMPL_3$ = Cooked 'moi-moi' from plantain leaf (Day 3). LSD = Least Square Difference.

Values are Means ± standard deviation of duplicate determinations. Means with the same superscripts within the same columns arenot significantly (p>0.05) different

There were no significant difference among the *'moi-moi'* samples in mouthfeel, taste, aftertaste perception and general acceptability but differed significantly in appearance and aroma. The *'moi-moi'* sample from plantain leaf had the least score in appearance while that from aluminium foil had the least in aroma. However, by the third day (day 3), the *'moi-moi'*; samples differed significantly in appearance, mouthfeel, taste, aroma and general acceptability.

Although preference for appearance decreased with increased storage time, *'moi-moi'* cooked in polymer film was most preferred on day 0 and day 3. This could be attributed to its brighter colour as compared to the slightly darker appearance of *'moi-moi'* cooked in plantain leaf and aluminium foil as a result of possible migrations from their respective cook-in packages. Similar results were recorded by Ezeocha *et al.* [3].

4. CONCLUSION

The results obtained in this work showed evidence of migration of compounds from the three packaging materials (polyethylene, aluminium and plantain leaf) used in the cooking of the '*moi-moi*". Even though the concentrations of the migrants from the different packaging materials were relatively low, it was observed that the concentrations of most of the migrants increased with increase in contact time hence, *'moi-moi'* cooked in these packaging materials can be said to be safe but caution should be taken to prevent accumulation of these compounds over time. Also, packaging materials used in cooking of *'moi-moi'* has been shown to affect the proximate composition and sensory qualities of the cooked *'moi-moi'*.

Based on the results of this study, polyethylene film and aluminium foil are recommended as cooking packaging materials for *'moi-moi'*. Plantain leaf which has gained wide acceptance as safest cook-in material for *'moi-moi'* because it is considered a natural material should be used with caution owing to the fact that it could be contaminated with heavy metals, fumes and pesticides from the soil, air and water. However, the safety associated with the packaging materials used in this work could be attributed to the duration of the contact time (storage) hence, further studies is required to investigate the safety of these materials when used beyond the three day threshold adopted in this study. Also there is need to investigate on the level of pesticide residues on plantain leaf as affected by location.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Guerreiro TM, Noin de Oliveira D, Melo CF, Lima E, Catharino RR. Migration from plastic packaging into meat. Food Research International. 2018;109:320-324.
2. Fweja LW. Plastic packaging materials as possible source of hazardous chemicals to food and human health: A review. Huria Journal. 2020;27(1).
3. Ezeocha VC, Unaegbu AO, Okereke AN. Effects of different packaging materials on the chemical and sensory properties of *'moi-moi'*. Nigerian Agricultural Journal. 2021;52(1):201-211.
4. Muncke J, Andersson A, Backhaus T, Boucher JM, Almroth BC, Castillo AC, et al. Impacts of food contact chemicals on human health: A consensus statement. Health. 2020;19:25.
5. Rodriguez BA, Cardama A, Sendon R, Ibrra V. Food contamination by packaging: Migration of chemicals from food contact materials. Berlin, Boston: De Gruyter; 2019.
6. Schneider K, Schwarz MA, Lindtner O, Blume K, Heinemeyer G. Lead exposure from food: the german LExUKon project. Food Additives and Contaminants. Part A, Chemistry, Analysis, Control, Exposure & Risk Assessment. 2014;31(6):1052–1063.
7. World Health Organization (WHO). Guidelines for drinking water: Fourth edition incoporating the first addendum. WHO Library Cataloguing-In-Publication Data; 2017.
8. European Food Safety Authority (EFSA). Update of the Risk Assessment of Dibutyl Phthalate (DBP), Butyl-Benzyl-Phthalates (BBP), Bis (2-Ethylhexyl) Phthalates (DEHP), Di-Isononyl Phthalate (DINP) and Di-Isodecyl Phthalate (DIDP) for use in Food Contact Materials. EFSA Journal. 2019;12(17).
9. Alamri MS, Qasem AA, Mohamed AA, Hussain S, Ibraheem MA, Shamlan G, Alqah HA, Qasha AS. Food packaging materials: A food safety perspective. Saudi Journal of Biological Sciences, 2021;28(8): 4490-4499.

10. Geueke B, Groh K, Maffini M, Martin O, Boucher J, Chiang Y, et al. Systemic evidence on migrating and extractable food contact chemicals: most chemicals detected in food contact materials are not listed for use. Critical Reviews in Food Science and Nutrition; 2022.
DOI: 10.1080/10408398.2022.2067828
11. Beleya EA, Eke-Ejiofor J. Proximate, Mineral and Sensory Attributes of *'moi-moi'* and "Epiti" Wrapped with Different Local Leaves in Nigeria. Research Journal of Food and Nutrition. 2020;4(2):13 - 19.
12. APHA (American Public Health Association). Standard methods: For the examination of metals in blood. 1995;20th Edition, APHA, AWWA, WEF/1995, APHA Publication.
13. AOAC. Association of Analytical Chemistry. Methods for chemical Analysis. 1990;2217–2280.
14. Onwuka GI. Food analysis and instrumentation. Theory and practices. Revised edition. Naphtali Prints Lagos, Nigeria. 2018;10-20.
15. 15. Bede EN, Mmuoasinam BC, Onuegbu NC, Ahaotu NN, Peter-Ikechukwu AI. Maize Cob as Dietary Fiber Source for High Fiber Biscuits. GSC Biological Pharmaceutical Sciences. 2020;12(1): 138-144.
16. Iwe MO. Current trends in sensory evaluation of foods. Revised Ed. Rojoint Communication Services Ltd. Uwani Enugu, Nigeria: 2014;144-145.
17. Okwunodulu IN, Peter GC, Okwunodulu FU. Proximate quantification and sensory assessment of *'moi-moi'* prepared from bambara nut and cowpea flour blends. Asian Food Science Journal. 2019;9(2):1-11.
18. Kumar V, Vinayak AK, Venkatachalam S, Muruganandam L. *Moi*sture barrier behavior of polymer films on food packaging plastic materials. International Journal for Technological Research in Engineering. 2022;9(5):6-12.
19. Iwuagwu CC, Okonkwo NJ. Effects of moisture barrier and initial moisture content on the storage life of some horticultural produce in evaporative coolant. African Journal of Biotechnology. 2014;13(8):944-950.
20. APHA (American Public Health Association). Standard methods: For the examination of metals in blood. 1995; 20th Edition, APHA, AWWA, WEF/1995, APHA Publication.
21. Sanusi RA, Odukoya GM, Ejoh SI. Cooked yield and nutrient retention values of selected commonly consumed staple foods in South-West Nigeria. African Journal of Biomedical Research. 2018;21:147-151.
22. Tyagi SB, Kharkwal M, Saxena T. Impact of cooking on nutritional content of food. DU Journal of Undergraduate Research and Innovation. 2015;1(3):180-186.
23. Dosumu OO, Akinnuonye GA. Effect of steaming of beans pudding on the phytochemical composition of *Thaumatococcus danielli* wrapper. Nigerian food Journal*.* 2015;32(1):110-116.
24. Ellen B Eke-Ejiofor J. Proximate, mineral and sensory attributes of *'moi-moi'* and "Epiti" wrapped with different local leaves in Nigeria. Research Journal of Food and Nutrition. 2020;4(2):13-19.
25. Akujobi IC, Amadi JAC. Nutrient composition and sensory properties of *'moi-moi'* produced from soy beans (*Glycin max*), haricot beans (*Phaseolous vulgaris*), and their blends. IMSU International Journal of Entrepreneurial Development. 2018;2(1):54-68.
26. Codex Alimentarius. General standard for contaminants and toxins in food and feed. CXS 193-1995, Revised in 2009; Ammended in 2019.
27. Fasoyiro SB. Locally processed street-vended foods in Nigeria: How safe?. International Journal of Safety and Security Engineering. 2012;2(4):381-391
28. Arvanitoyannis IS, Kotsanopoulos KV. Migration phenomenon in food packaging. Food–Package Interactions, Mechanisms, Types of Migrants, Testing and Relative Legislation - A Review. Food Bioprocess Technologuy. 2014;7:21–36.
29. Hussein HA, Salman MN, Jawad AM. Effect of freezing on chemical composition and nutritional value in meat. Drug Invention Today. 2019;13(2):329-333.
30. Birnbaum LS, Schug T. Phthalates in our food. Endocrine Disruptors. 2012;1(1).
31. Moreira MA, Andre LC, Cardeal ZL. Analysis of phthalate migration to food simulants in plastic containers during microwave operations. International Journal of Environmental Research and Public Health. 2014;11(1):507-526.
32. Right to Know Hazardous substance fact sheet: Isoprene. New Jersey Department of Health*.*

33. Naik HR. Persistence and dissipation of dichlorvos and profenofos on mulberry leaves. Madras Agriculture Journal. 2012;99:583-585.
34. Mattina M, Berger W, Dykas L. Chlordane uptake and its translocation in food crops. Journal of Agricultural and Food Chemistry. 2000;48:1909-1915.
35. NAFDAC. List of Banned Pesticides in Nigeria. Available:www.nafdac.gov.ng. Accessed 10th June, 2022.
36. World Health Organization (WHO). Pesticide Residues in Food; 2018. Accessed May 8th, 2022.
37. Waliszewski SM, Carvajal O, Infanzon RM, Trujillo P, Aguirre AA, Maxwell M. Levels of organochlorine pesticides in soils and rye plant tissues in a field study. Journal of agricultural and food chemistry. 2004; 52(23):7045-50.
38. Kelle HI, Ogoko EC, Abiola OO, Achem D, Udeozo IP. Monitoring and health risk assessment of organochlorine pesticide residue in some leafy and fruiting vegetables from Lagos State, Southwestern Nigeria. Journal of the Kenya Chemical Society. 2022;15(1): 3-13.
39. Gwary OM, Hati SS, Dimariand GA, Ogugbuaja VO. Pesticide residues in bean samples from Northeastern Nigeria. significance. 2011;1(2).

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97585