A TIME COURSE STUDY ON BLOOD CHEMISTRY AND HAEMATOLOGICAL PARAMETERS OF ALBINO RATS EXPOSED TO MICROWAVED PELLETS

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ABSTRACT

Different studies have implicated radiations in diverse health anomalies including genetic mutations and carcinogenesis. The present study sought to investigate any changes in vital blood chemistry indices following intake of micro wave pellet over different lengths of time using animal model (Wistar rats). Thirty-six adult male rats were randomized into three groups (n = 12). Group 1 animals (control) were fed with normal pellets; groups 2 and 3 animals were respectively fed with indirectly and directly micro waved pellets, and water ad libitum. Four animals were sacrificed weekly for three weeks from each group and blood samples were collected by cardiac puncture for biochemical analyses. Plasma levels of total protein, cholesterol, triglyceride, high density lipoprotein (HDL), low density lipoprotein (LDL), alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), bilirubin and haematological indices were determined using standard procedures. Comparative analyses of the control and experimental groups showed that intake of micro waved pellets (both direct and indirect) caused significant ($p<0.05$) alterations in the physiological levels of total cholesterol, total triglyceride, HDL, LDL, ALP, AST, ALT, total protein, total and indirect bilirubin, by the third week. Although, these parameters did not significantly changed within the first two weeks, but significant ($p<0.05$) changes in haematological parameters were noticed right from the first week of micro waved pellet intake. Collectively, the outcome of this study apparently substantiates the health risk commonly associated with the intake of micro waved food and therefore discourages its consumption.

Keywords: Microwave pellet, Health risk, Blood chemistry, Haematology, Rat

INTRODUCTION

Microwaves are very short waves of electromagnetic energy and part of Mother Nature's energy spectrum. This spectrum contains frequencies with wave length from the longest to the shortest: radio waves, microwave, infrared, optical, ultraviolet, x-rays and gamma rays. High frequency electromagnetic field (EMF) is generated from different sources such as radar installations, radio and television transmitters and microwave ovens. Microwave radiation is a type of non-ionizing electromagnetic radiations and

considered as environmental pollutant (Paulraj and Behari, 2004). The microwave radiation exposure causes biological effects in living organisms. The increase usage of microwave radiation equipment at home and industry is becoming a major cause for concern due to daily alarm on its health risks. The most commonly used in domestic and industrial food preparation is 2.45 GHz microwave radiation. The radiation leakage from improperly maintained ovens is a source of environmental pollution and has the propensity to endanger human health (Parkar *et al.*, 2010). The process of microwave heating of food has been extensively studied (Nott and Hall, 2005; Elghazaly *et al.*, 2014; Eke *et al.*, 2015; 2017). The enormous amount of energy going into the food molecules from microwave radiation is sufficient to break protein molecules, thus creating a lot of strange new molecules from the denaturation of protein. The molecular structure of the food is changed, the produced molecules is unnatural to the body and is considered as a carcinogenic substance. The disorders in the digestive system resulting from eating the microwave heated food as well as nutritional quality of food decreased by 60 to 90 % (Lee, 1994). Blood parameters are probably the more rapid and detectable variations under stress and are used in assessing the health status (Goodwin *et al.*, 2007; Ikanone *et al.*, 2017). It also acts as a pathological reflector of the whole body (Khan *et al.*, 2009).

Haematological parameters have been associated with health indices and are of diagnostic significance in routine clinical evaluation of the state of health (Lee, 1994). The blood is a vital fluid, which contains the red blood cell (RBC), white blood cell (WBC) and platelets suspended in the plasma in homeostatic concentrations. The circulatory blood volume makes up to about 8 % of the weight of an average man. The blood cells take up about 45 % of the blood, while plasma constitutes about 55 %. The packed cell volume (PCV) measures the percentage by volume of packed RBC in a whole blood sample after centrifugation. The haemoglobin (HGB) concentration measures the amount of HGB in grams in 1 dl of whole blood and provides an estimate of oxygen carrying capacity of the RBC. The blood differential test measure the percentage of each type of WBC in the blood (Eke *et al.*, 2015).

Microwave oven which produces radiation used in cooking and heating of food for consumption poses a great health consequence; hence this study is designed to investigate its effect on the haematological and blood chemistry parameters of albino rats fed microwave pellets. The outcome of these results will provide more robust information and also go a long way in bringing more understanding to the changes that occur in the body as a result of ingestion of microwave food using animal model.

MATERIALS AND METHODS

Collection and Management of Animals: Male adult albino rats of the Wistar strain weighing between 120 to 180 g were used for the study. They were obtained from the animal breeding unit of Institute for Advance Medical Research and Training (IMRAT), at the University College Hospital (UCH), Ibadan. All procedures for maintenance and sacrifice (care and use) of animals were carried out according to the criteria outlined by the National Academy of Science published by the National Institute of Health (NIH, 1985). The animals were handled humanely, kept in plastic suspended cages, placed in a well-ventilated and hygienic rat house under prevailing temperature and humidity conditions. They were provided rat pellets (Vital Feeds - 18 % crude protein, 2800 kcal/kg metabolizable energy) and water *ad libitum* and subjected to normal photoperiodic light and dark cycle. The animals were allowed two weeks of acclimatization prior to the commencement of study.

Experimental Design: The experiment was laid in a complete randomized block design of three treatment groups replicated thrice with each replicate having four rats. Group 1 animals (control) were fed with normal pellets; Groups 2 and 3 animals were respectively fed with indirectly (covered and microwaved) and directly (uncovered and microwaved) pellets (Table 1).

Table 1: Experimental design for the study on the blood chemistry and haematological parameters of albino rats exposed to microwaved pellets

Experimental group	Nature of exposure to microwave radiation	Nomenclature
Group 1	Rat pellets not exposed to microwave oven	Control
Group 2	Rat pellets exposed to microwave radiation in aluminium plate with cover (Indirect exposure)	Covered
Group 3	Rat pellets exposed to microwave radiation in aluminium plate without cover (Direct exposure)	Exposed

The rat pellets were microwave for 1 minute 30 seconds in the microwave oven (LG Model C25MW09, China). All the animals were allowed equal access to their respective experiment pellets and water *ad libitum* throughout the study. The feeding lasted for three weeks after acclimatization and data for the studied parameters were obtained weekly.

Animal Sacrifice and Blood Collection: Four animals were sacrificed weekly from each group for three weeks after overnight fast and blood samples were collected by cardiac puncture into EDTA bottles. Some portion of the blood was centrifuged at 4000g for 10 minutes to separate the serum which was used for the biochemical analyses, while the other portion was used for haematology determination within 24 hours.

Biochemical Assays: The activities of alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were estimated by the use of end point colourimetric diagnostic kit (Randox Laboratories Limited, England) according to the method of Reitman and Frankel (1957). Alkaline phosphatase (ALP) activity was determined by the use of sigma diagnostic kits (Sigma Diagnostic, USA) according to the method of Englehardt (1970). The concentrations of total plasma protein, total and direct bilirubin levels were estimated using sigma diagnostic kits (Sigma Diagnostic, USA).

Total cholesterol (TCHOL) and total triglycerides (TAG), low density lipoprotein (LDL) cholesterol (LDL-C) and high density lipoprotein (HDL) cholesterol (HDL-C were determined using test kits (Linear Chemicals). The haematological parameters evaluated were white blood cell (WBC), haemoglobin (HGB), red blood cell (RBC) and haematocrit (HCT) or pack cell volume (PVC). They were measured using automated Haematology Analyzer (Cbc-6000, USA).

Statistical Analysis: Data obtained from the different parameters studied were subjected to analysis of variance (ANOVA) to test for the level of homogeneity and the Duncan multiple range test was used to separate means were heterogeneity occurred. P values at < 0.05 was considered significant using IBM SPSS version 20. The results were expressed as mean ± standard error of mean.

RESULTS

Effect of the microwaved pellets intake on the body weight of rats: The effect of microwaved pellet intake on the body weight of rat indicated that the entire rat had significant ($p<0.05$) weight gain throughout the duration of the experiment (Table 2). Rats of the exposed group (directly exposure to microwave radiation) had significant ($p<0.05$) weight gain when compared with the control group, while rats from the covered group (indirect exposure) equally had significant ($p<0.05$) weight gain when compared with the control group.

Effect of the microwaved pellets intake on the total protein, direct and total bilirubin of rats: There was no significant differences ($p>0.05$) in the total protein concentration of the exposed and covered groups when compared with the control animals in the first and second weeks respectively, but significant alteration was observed in the third week. Similar trend was also observed for direct and total bilirubin concentrations (Table 3).

Table 2: Effect of microwaved pellet intake for different duration (days) on the body weight of rats

Experimental groups	Mean body weight (g)	7 days	14 days	21 days
Control (Group 1)	Initial weight	126.00 ± 1.41^{a}	134.00 ± 1.41^{b}	155.00 ± 0.71^{c}
	Final weight	148.00 ± 2.83^{a}	155.00 ± 2.12^{b}	170.00 ± 1.41^{c}
	Weight gained	22.00^{a}	21.00^{a}	25.00^{b}
Covered (Group 2)	Initial weight	128.00 ± 1.41^{a}	130.00 ± 2.12^{b}	152.00 ± 1.41^{c}
	Final weight	137.00 ± 1.41^{a}	140.00 ± 2.12^{b}	167.00 ± 0.71^{c}
	Weight gained	9.00^{a}	12.00^{b}	15.00^{c}
Exposed (Group 3)	Initial weight	135.00 ± 3.54^{a}	145.00 ± 1.41^{b}	156.00 ± 0.71^{c}
	Final weight	175.00 ± 1.41^{a}	180.00 ± 0.71^{b}	190.00 ± 2.12^{c}
	Weight gained	40.00^{b}	35.00^{a}	34.00^{a}

Mean values on a row with heterogeneous superscripts letters are significant different (p≤0.05)

Table 3: Effect of microwaved pellet intake for different duration (days) on the total protein, direct and total bilirubin of rats

Experimental groups	7 days	14 days	21 days
		Total protein (µmol/L)	
Control (Group 1)	5.91 ± 0.15^{a}	5.98 ± 0.08^{a}	6.76 ± 0.06^{b}
Covered (Group 2)	5.53 ± 0.11^{a}	5.90 ± 0.07^{b}	6.80 ± 0.28^{c}
Exposed (Group 3)	4.99 ± 0.29^{a}	5.88 ± 0.12^{b}	6.38 ± 0.03^{c}
		Direct bilirubin (mmol/L)	
Control (Group 1)	0.51 ± 0.03^{a}	0.68 ± 0.01^{b}	0.70 ± 0.14^{c}
Covered (Group 2)	0.05 ± 0.01^{a}	0.09 ± 0.01^{b}	0.09 ± 0.01^{b}
Exposed (Group 3)	0.60 ± 0.07^{a}	0.76 ± 0.06^{b}	0.79 ± 0.05^{b}
		Total bilirubin (µmol/L)	
Control (Group 1)	0.76 ± 0.06^{b}	0.45 ± 0.01^{a}	0.81 ± 0.01^{c}
Covered (Group 2)	0.32 ± 0.01^{a}	0.79 ± 0.01^{c}	0.46 ± 0.01^{b}
Exposed (Group 3)	0.08 ± 0.01^{a}	0.88 ± 0.04^{b}	0.90 ± 0.01^{b}

Mean values on a row with heterogeneous superscripts letters are significant different (p≤0.05)

Effect of the microwaved pellets intake on AST, ALT and ALP activities of rats: Table 4 indicated that AST, ALT and ALP activities of the exposed and covered groups significantly increased ($p<0.05$) when compared with the control animals. AST activity increased significantly ($p<0.05$) in the exposed group when compared with the control and covered groups, while animals in covered groups increased significantly ($p<0.05$) when compared to the control group. Similar trend was also observed for ALT and ALP activities. The activities of these enzymes increased with the duration of feeding.

Effect of the microwaved pellets intake on lipid parameters of rats: As shown in Table 5, the levels of triglyceride, cholesterol, LDL and HDL of the exposed and covered groups significantly increased ($p<0.05$) when compared with the control animals in the third week. Triglyceride levels of the exposed group increased significantly ($p<0.05$) when compared with the covered and control groups. Similar trends were also observed for cholesterol, LDL and HDL levels.

Effect of the microwaved pellet intake on haematological parameters of rats: As depicted in Table 6, the levels of WBC, HGB, RBC and HCT showed significant changes ($p<0.05$) from the first week of food intake (experimental groups) to the third when compared with the control group.

Table 4: Effect of microwaved pellet intake for different duration (days) on the *aspartate aminotransferase (AST), alanine aminotransferase (ALT)* and *alkaline phosphatase (ALP)* activities of rats

Experimental groups	7 days	14 days	21 days
	Aspartate aminotransferase		
Control (Group 1)	4.48 ± 0.04[a]	4.96 ± 0.08[b]	5.09 ± 0.01[b]
Covered (Group 2)	4.93 ± 0.11[a]	5.98 ± 0.04[b]	6.93 ± 0.11[c]
Exposed (Group 3)	6.98 ± 0.04[a]	7.83 ± 0.25[b]	9.03 ± 0.04[c]
	Alanine aminotransferase		
Control (Group 1)	4.03 ± 0.04[a]	4.26 ± 0.08[a]	5.11 ± 0.27[b]
Covered (Group 2)	5.98 ± 0.04[a]	6.17 ± 0.04[a]	7.19 ± 0.01[b]
Exposed (Group 3)	7.99 ± 0.01[a]	8.55 ± 0.49[b]	9.17 ± 0.05[c]
	Alkaline phosphatase		
Control (Group 1)	21.93 ± 0.11[a]	23.02 ± 0.03[b]	25.57 ± 0.81[c]
Covered (Group 2)	25.90 ± 0.14[a]	27.99 ± 0.01[b]	30.03 ± 0.04[c]
Exposed (Group 3)	35.83 ± 0.25[a]	38.51 ± 0.71[b]	40.50 ± 0.71[c]

Mean values on a row with heterogeneous superscripts letters are significant different (p≤0.05)

Table 5: Effect of microwaved pellet intake for different duration (days) on the lipid parameters of rats

Experimental groups	7 days	14 days	21 days
	Triglyceride (mg/dL)		
Control (Group 1)	18.99 ± 0.02[a]	19.88 ± 0.18[a]	21.93 ± 0.09[c]
Covered (Group 2)	19.93 ± 0.11[a]	21.93 ± 0.11[b]	24.56 ± 0.62[c]
Exposed (Group 3)	25.90 ± 0.14[a]	28.51 ± 0.71[b]	29.93 ± 0.11[c]
	Cholesterol (mg/dL)		
Control (Group 1)	31.91 ± 0.13[a]	34.83 ± 0.25[b]	37.96 ± 0.06[c]
Covered (Group 2)	34.99 ± 0.01[a]	38.16 ± 0.23[b]	40.51 ± 0.71[c]
Exposed (Group 3)	39.78 ± 0.32[a]	44.50 ± 0.71[b]	46.51 ± 0.71[c]
	Low density lipoprotein (mg/dL)		
Control (Group 1)	10.44 ± 0.18[a]	13.98 ± 0.28[b]	15.78 ± 0.32[c]
Covered (Group 2)	10.40 ± 0.33[a]	13.07 ± 0.09[b]	13.77 ± 0.33[b]
Exposed (Group 3)	10.45 ± 0.23[a]	14.07 ± 0.10[b]	16.96 ± 0.06[c]
	High density lipoprotein (mg/dL)		
Control (Group 1)	14.95 ± 0.08[a]	17.51 ± 0.04[b]	18.96 ± 0.06[c]
Covered (Group 2)	18.98 ± 0.03[a]	20.04 ± 0.05[b]	21.98 ± 0.04[c]
Exposed (Group 3)	20.93 ± 0.11[a]	22.93 ± 0.11[b]	25.50 ± 0.71[c]

Mean values on a row with heterogeneous superscripts letters are significant different (p≤0.05)

DISCUSSION

The increase usage of microwave radiation equipment at home and industry makes adverse concern about the effect of microwave leakage on biological systems. Microwave technology has been widely used in different fields in our lives (microwave oven, WIFI and cell phones) (Mathur *et al.*, 2013). A microwave oven or a microwave is a kitchen appliance that cooks or heat food by dielectric heating or cooking which requires minimum time and energy. It is also good for domestic purpose but it has several drawbacks on the nutritional contents of the food (Kushwaha, 2012). The most frequency commonly used in domestic and industrial food preparation is 2.45 GHz microwave radiation. The radiation Leakage from improperly maintained ovens is a source of environmental pollution and may posed risk on human health (Parkar *et al.*, 2010).

There was significant increase in the body weight of the animals in experimental group compared to the control animals.

Table 6: Effect of microwaved pellet intake for different duration (days) on the haematological parameters of rats

Experimental groups	7 days	14 days	21 days
		White blood cell (x 10^9/L)	
Control (group 1)	4.00 ± 0.14^a	9.35 ± 0.07^b	9.90 ± 0.28^c
Covered (group 2)	4.16 ± 0.19^a	7.95 ± 0.08^b	8.15 ± 0.21^b
Exposed (group 3)	7.43 ± 0.11^c	5.05 ± 0.21^a	5.75 ± 0.35^b
		Haemoglobin (g/dL)	
Control (group 1)	110.50 ± 0.71^a	148.50 ± 0.70^b	150.50 ± 0.71^c
Covered (group 2)	121.00 ± 1.41^a	139.50 ± 0.71^b	141.50 ± 0.71^c
Exposed (group 3)	134.50 ± 0.71^c	128.50 ± 0.71^a	131.00 ± 1.41^b
		Red blood cell (mcL)	
Control (group 1)	5.99 ± 0.04^a	8.00 ± 0.14^b	7.95 ± 0.08^b
Covered (group 2)	5.34 ± 0.11^a	7.14 ± 0.08^b	7.29 ± 0.01^b
Exposed (group 3)	7.31 ± 0.02^b	6.93 ± 0.12^a	7.14 ± 0.26^b
		Packed cell volume (%)	
Control (group 1)	36.98 ± 0.04^a	48.45 ± 0.64^b	48.98 ± 0.39^b
Covered (group 2)	30.22 ± 0.61^a	42.90 ± 0.14^b	43.90 ± 0.28^c
Exposed (group 3)	40.25 ± 0.08^a	40.50 ± 0.57^a	41.09 ± 0.16^b

Mean values on a row with heterogeneous superscripts letters are significant different ($p \leq 0.05$)

This may be attributed to the fact that rat pellet exposed directly to the microwave radiation enhances palatability which created an irresistible aroma that trigger the consumption of the pellets voraciously leading to increased metabolic rate and consequently increase in body weight of the exposed rats. This was closely followed by the covered group compared to the control animals. This observation is similar to the report of Eke *et al*. (2017).

Proteins are essential and indispensable to the functional and structural integrity of body cells and tissues. They are primarily synthesized in the liver, found in organs, tissues and membrane, and a compromise in protein system is the basis for several disease conditions or pathologies (Ighodaro and Akinloye, 2018).

The increase in protein concentration though not significant in the third week (21 days) was as a result of prolonged exposure of radiation emitted from the microwave oven into the rat pellet. This result was in agreement with the works of Bohr and Bohr (2000) who studied the effect of electromagnetic waves exposure on denaturation of globular proteins. According to the authors, there was an increase in biological activity of protein concentrations according to the effect of microwave radiation leakage. The changes in ligand binding properties of cellular proteins can affect their function. Calcium is one of such ligands which may alter the formation of protein. Moussa (2009) had earlier reported similar finding that there was an increase in protein levels in experimental mice when exposed to microwave radiation. The increase in total and direct bilirubin levels observed in the rats exposed to microwave radiation may be an indication of hepatobiliary disease. The current results are in agreement with Moussa (2009) who stated that there was an increase in bilirubin concentration when mice were exposed to 3.5 GHz microwave radiation.

Aspartate aminotransferase (AST) and ALT activities in the serum are often associated with hepatocellular damage (El Hilaly *et al*., 2004). Serum alkaline phosphatase (ALP) is a sensitive detector in biliary cirrhosis, hepatitis and in diseases characterized by inflammation, regulation, intrahepatic and extrahepatic bile obstruction (Witthawaskul *et al*., 2003). After 21 days of exposure to radiation, the test groups showed significant increase in ALP, AST and ALT activities. The increased levels of ALP, AST and ALT activities are conventional indicators of liver injury (Shah *et al*., 2011). This observation was in agreement with (Eke *et al*., 2017). These serum enzymes (ALT and AST) are largely used in assessment of liver damage by any foreign agent in the body (Ramaiah, 2011; Patrick-

Iwuanyanwu *et al*., 2012). The elevation of serum marker enzymes observed in the study may be attributed to severe hepatocellular injury caused by the ingestion of absorbed radiation from the rat pellets with increase in length of days of feeding. The rise in the enzymes AST and ALT activities observed in the study was in agreement with the findings of Stuchly (1995) and Shen *et al*. (2005). Although these authors did not adopt the same experimental approach, they were able to arrive at this deduction. Elevated AST activity is an indication of liver damage (Crook, 2006). Increased levels of serum enzymes are indicative of cellular leakage and loss of functional integrity of cell membrane in the liver and other organs (Crook, 2006). The cellular leakage may be attributed to the harmful effect of radiolytic compounds (carcinogenic in nature) formed as a results of deformation done to the nutrients present in the rat pellets.

The effect of microwave radiation on the lipid profile of rats was also studied in the current investigation. Lipid profile is the term that collectively describes the amounts of total cholesterol, total triglycerides, low density lipoprotein cholesterol and high density lipoprotein cholesterol in milligram per decilitre. It may also involve phospholipids and other lipids. This profile is used to access the risk of cardiovascular disorders (CVDs) and is altered in the serum of various disease states (Betteridge, 1994). Except for HDL cholesterol, high level of all lipids in the blood is arguably a risk factor in the etiology and progression of cardiovascular disorders (Eisenhauer *et al*., 1998). LDL is one of the lipoprotein components of the blood. It transports cholesterol mainly to the arterial wall. This results in the accumulation of insoluble lipid on the wall of the arteries thereby reducing blood flow and increases the pressure on the wall as well as the heart.

The deposition of cholesterol on the arterial wall results in a condition known as arteriosclerosis which is the major cause of cardiovascular disorders. In contrast, HDL-cholesterol binds to arterial cholesterol and transports it to the liver for metabolism. People with high levels of HDL-cholesterol seem to have fewer problems with CVDs, while those with low HDL-cholesterol have increased rate of CVDs. Thus, substances that increase the plasma HDL-cholesterol and decrease LDL-cholesterol will play an important role in reducing the risk of CVDs.

In this study, microwave radiation (direct and indirect) exposure was observed to cause significant increase of lipid parameters (triglyceride, cholesterol, LDL-cholesterol and HDL- cholesterol) investigated in the third week. The increase was more in the exposed group (direct) when compared with the covered group (indirect) within the different length of microwave heating. The food nutrients were more affected under direct exposure to radiation though for the case of indirect exposure, the nutrients were also affected but with minimal impact. As the duration (days) of microwave food increases within the days under study, there was also an increase in body lipids. Ingestion of deformed molecules could have stimulated lipogenesis which accounts for the increase in lipid parameters experienced from the study. This view was in agreement with the findings of Raghuvanshi and Mathur (2013). They recorded increased serum cholesterol in serum of mice fed on microwave exposed food. On the other hand, Ahmad *et al.* (2011) showed no differences in plasma triglycerides of rats fed microwaved corn oil for five weeks. The view of Serror *et al*. (2014) supported the outcome of this study. These authors reported that microwave food cause alteration in serum lipid levels amongst other parameters investigated. Hyperlipidaemia and body stress have been shown to be prognostic in the development of several degenerative diseases such as coronary heart disease (Essien *et al*., 1992).

The WBC count decreases significantly in the exposed group (direct) with increase in length of microwave heating within the different period under investigation when compared with the covered (indirect) and control groups.. This may be related to the destruction of nutritive value of microwave food. The slight but non-significant decrease in RBC count in the exposed group when compared with the covered and control groups may be due to failure of erythropoietin production (Ikpi and Nku, 2008). This could lead to anaemia. The pack cell

volume also known as haematocrit represents the percentage of RBC in blood. There is a direct relationship between RBC, HCT and HGB concentration (Schalm *et al*., 1975). Hence, a decrease in one parameter results in a decrease in others. HGB and HCT decrease significantly in the exposed group than the covered group when compared with the control group. The reason for the decrease has been explained earlier. This result agrees with the findings of Mathur *et al*., (2013) whose study on the effect of microwave exposed mice feed on the haematological parameters of Swiss albino mice showed a significant decrease in RBC, PCV or HCT and HGB concentration at all autopsy intervals and at the microwave power of 320W and exposure time of ten minutes. The experimental design is quite different from the one used in the present study.

Conclusion: This study shows that microwave oven affects the food adversely whether covered or exposed which consequently can lead to a number of health issues. The study therefore discourages the prolonged use of microwave oven for heating and cooking of food. Experimental evidence from this study revealed that exposure to microwave food can affect blood chemistry and Haematological parameters adversely.

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