PRINT ISSN 1119-8362
Electronic ISSN 1119-8362

Full-text Available Online at
https://www.ajol.info/index.php/jasem
http://ww.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 25 (11) 1915-1919 November 2021

Consequences of Thermal Induced Radiation from Ovens on the Physiology of Bakery Workers in Calabar, Cross Rivers State, Nigeria

KAMGBA, FA

Department of Physics, Cross River University of Technology, Calabars, Nigeria
**Email of corresponding author: fkamgba@gmail.com*

ABSTRACT: Consequences of thermal induced radiation from ovens on the physiology of Bakery workers in Calabar, was investigated. An in-situ measurement approach to estimate the impact of thermal radiation on human physiological changes. The relationships between the measured temperature parameters were correlated with a questionnaire inventory. Statistical analysis of the questionnaires based on the relevant hypotheses was carried out. The results show that, the P-values of 0.005; 0.001; 0.006; 0.001 and 0.001 less than 0.05 in all cases and was prevalent. The statistical result implies that there is a significant effect of thermal radiation emanating from bakery ovens on the physiology of workers as this was used to establish the wellbeing of workers in the perceived heat stressed environment. It also was found out that the exposure of workers to thermal radiation in all the bakeries under study exceeded the WHO (20^{o}C- 29^{o}C) exposure limit for comfort. All the bakeries visited during this study used firewood industrial oven.

DOI: https://dx.doi.org/10.4314/jasem.v25i11.10

Dates: Received: 22 August 2021; Revised: 17 September 2021; Accepted: 06 October 2021

Keywords; Temperature, Radiation, Oven, bakery; Workers, Physiology

Thermal radiation is simply referred to as heat energy. Heat is generally understood as the transfer of energy due to temperature changes between two bodies in close contact or a measure of the average kinetic energy of the particles in a sample of matter (Arora, and Rama Raju 2006). Thermal radiation generated in most work places as a result of hike in temperature especially from bakery ovens is seen to pose both environmental and health related threats to both man and animals. Studies by Beheshti *et al.*, (2016) reveals that thermal stress due to heat is caused by both internal and external thermal factors which have an overriding effect on human fatigue and development of disease condition. He also opined that environmental heat influences the performance and productivity of humans through changing physiological parameters, such as blood flow and hormonal release rate. He also observed that there is an unbalanced regulatory mechanism in human body when the temperature reaches threshold value, tissue damage and/or alterations of biological processes may occur. Exposure of human to heat in a particular working environment especially workers of bakery ovens and oil and gas companies risk performance index in terms of efficiency, productivity as well as threat to their health conditions Emoyan et al.,(2008). It is thus predicted that physiological heat strain experienced by an individual will be related to the total heat stress to which he/she is exposed, serving the need to maintain body-core temperature within a relatively narrow ranges. Many attempts have been made to estimate the stress inflicted by a wide range of work conditions and climate, or to estimate the corresponding physiological strain and to combine them into a single index called a heat stress index (Kamgba, 2019). Golbabaei and Omidvari, (2008) in their studies of man and his environment asserted that, if the ambient temperature is outside of thermal comfort zones, the human body's thermal balance is lost, this he referred to as the heat stress. The heat stress, as a physical hazardous factor, is being raised in many workplaces. Brotherhood (1987) studies of heat stress states that "an increase in environmental temperature may result in greater stress than the combined capacities of thermoregulation and heat dissipation can handle". This condition will cause a dangerous increase in the athlete's body temperature and skin temperature, affecting his/her performance, as well as his/her health and safety. High temperature causes an increase in blood flow to the surface tissue, causing the heart to pump more blood to the muscles and to the skin resulting in a higher heart rate. Therefore it is pertinent to evaluate the effects of heat exposure on working people (including gender aspects and effects on pregnant women and on children) as suggested by Kjellstrom (2014). to quantify climate

** Corresponding Author Email: fkamgba@gmail.com*

change-related increases in workplaces, heat exposures and the impact this will have on human health and productivity in different locations around the world. Hence, the objective of this paper is to evaluate the consequences of thermal induced radiation on the physiology of bakery workers in Calabar, Cross River State, Nigeria.

MATERIALS AND METHODS

Description of Study Area: Calabar is the capital of Cross River State located in the southern part of Nigeria, experiences a rare type of climate known as the tropical monsoon climate with a mixture mangrove swamp and rainforest vergetation. Calabar is located on Latitude 4º57'06"N and longitude 8º19'19"E at an elevation of 42m above sea level (Edet *et al*, 2017). The points marked blue on the map show the location of the bakeries that were visited during the course of this investigation.

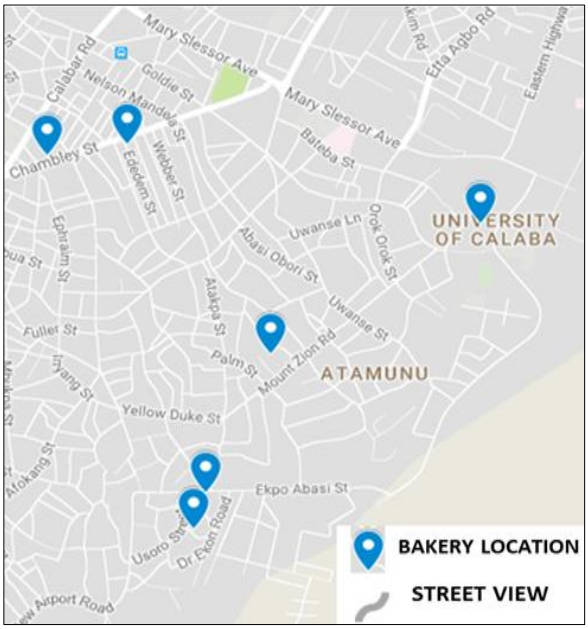

Fig 1. Map of the Study Location Kamgba, (2020) in Calabar, Cross River State, Nigeria.

Table 1: Showing Longitudes and Latitudes of surveyed Areas in Calabar Cross River State, Nigeria.

Location	Latitude	Longitude
Ekemini Bread (Effio-anwan Street) L1	$4^0$55'43.78" N	$8^0$19'38.14"E
Ekemini Bread(Atakpa Lane) L2	$4^0$56'22.56" N	$8^0$19'53.54"E
Ekemini Bread(Goldie by Mount Zion)L3	$4^0$56'51.44" N	$8^0$20'37.04"E
Spring Bread(Ededem Street) L4	$4^0$57'8.97"N	$8^0$19'24.72"E
Daybreak (Chamley Street) L5	$4^0$57'6.53"N	$8^0$19'8.16"E
Ekpo Abasi Street L6	$4^0$55'51.89" N	$8^0$19'40.83"E

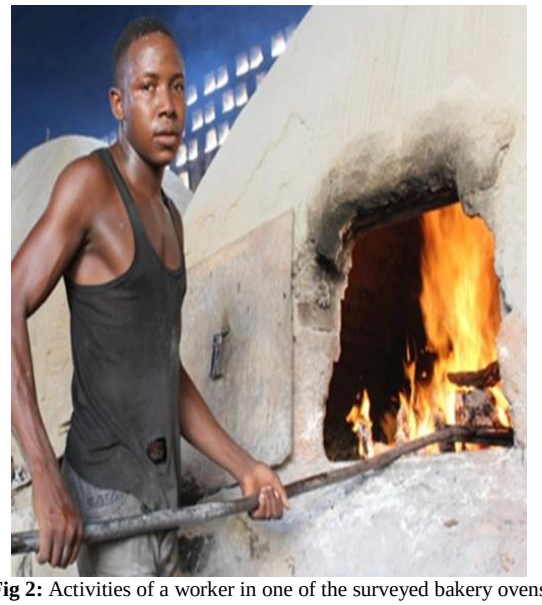

Fig 2: Activities of a worker in one of the surveyed bakery ovens in Calabar

Thermometer: Both clinical and environmental thermometers were used to measure the body temperatures of workers in different bakeries as well as the environmental temperatures of the areas under study

Meter Rule: A metre rule was used to measure the distance away from the source point (i.e. Oven), where the readings were taken.

Questionnaire: A questionnaire is an instrument used to measure the responses of people sample selected for the experiment. A questionnaire based on the hypotheses, there is no significant effect of thermally induced radiation from bakery ovens on it workers was generated with items skewed to health related problems and was issued to workers of the selected six ovens in Calabar south. This was to find out the extent of disease condition emanating from thermal radiation on workers in these bakeries. The responses by respondents were collected after two hours and statistical analysis carried out using independent T-test for the five different locations

Method of measuring Radiation: Temperature data in degree centigrade (ºC) were captured for varied distances from the source points using a digitized mercury in-glass. The body temperatures of worker were obtained by direct measurement in their armpit by using clinical thermometer. The data were collected from six bakeries in Calabar South environs, using fire wood oven.

Evaluation of data: The basic heat balance equation is:

$$\Delta S = (M - W_{ex}) \pm (R + C) - E \qquad (1)$$

Where: ΔS= change in body heat content;

$(M–W_{ex})$ =net metabolic heat production from total metabolic heat production

W_{ex}=mechanical work; M=Mass of the body; $(R + C)$=convective and radiative heat exchange;
E =evaporative heat loss.

In the situation of thermal balance ΔS=0, then:

$$(M–W_{ex}) \pm (R + C) = E_{req} \qquad (2)$$

This equation form defines the required evaporation to achieve thermal balance (E_{req}). Noteworthy, evaporative capacity of the environment is in most of the cases lower than E_{req}; and thus, the maximal evaporative capacity of the environment (E_{max}) should be considered. The ratio $\frac{E_{req}}{E_{max}}$, which denotes the required skin wettedness to eliminate heat from the body, is a "Heat Strain Index" (HSI) that was proposed by Belding and Hatch7 Epstein and Moran (2006).

The singular equations of $E_{req}$and E_{max} are beyond the scope of the present discussion; but, to solve these equations several parameters should be measured and eventually the interaction between them will define the human thermal environment Epstein and Moran (2006)

RESULTS AND DISCUSSION

The results of temperature measurements in degree centigrade from Tables 2a -6a show a corresponding decrease of temperature values from source point that there is degree centigrade. Tables 2a – 6a show temperature values in degree Celsius (ºC) with varied distances in metres from heat source for all locations under study. The tables also show the wind speed in ms^{-1} and body temperatures of workers in degree Celsius (ºC). These tables physically show the variations of temperature with distance away from the source point (oven) and human body temperatures. Tables 2b – 6b show statistical analysis of questionnaire of those working with the bakeries using independent sample t-test at a p-value of 0.05 test of significant.

Table 2a: Showing Temperatures of Ekemini Bakery Effio-Anwan Street Calabar South.

Distance (m)	Temperature around oven (ºC)	Ambient Temperature of the Bakery (ºC)	Wind Speed inside the bakery (ms^{-1})	Body Temperature of six workers (ºC)
Source Point	180	38	0.50	37.1
1	120	40	0.53	37.0
2	80	42	0.66	36.8
3	60	43	0.69	37.0
4	40	44	0.71	36.6
5	35	46	0.81	36.7

Table 2b: Independent Samples Test of effect of heat emanating from bakery on health of workers in Ekemini Bakery, Usoro Street Calabar South

	Levene's Test Equality Variances		fort-test for Equality of Means						
	F	Sig.	T	df	Significance\ . (2-tailed)	Mean Difference	Std. Error Difference	95% Interval of the Difference	Confidence of the
								Lower	Upper
Equal variances assumed	9.670	.014	3.825	8	.005	59.20000	15.47708	23.50979	94.89021
Equal variances not assumed			3.825	4.018	.019	59.20000	15.47708	16.30487	102.09513

P 0.005

Table 3a: Showing Temperatures of Ekemini Bakery at Atakpa Calabar South.

Distance (m)	Temperature around oven (ºC)	Ambient Temperature of the Bakery (ºC)	Wind speed inside the bakery (ms^{-1})	Body Temperature of six Workers (ºC)
source point	185	47.0	1.11	37.0
1	140	48.0	1.13	37.0
2	100	48.6	1.22	36.6
3	90	49.0	1.44	36.8
4	60	48.0	1.69	36.7
5	46	49.0	1.82	36.9

Table 3b: Independent Samples Test of effect of heat emanating from bakery on health of workers (Ekemini Bakery, Atakpa)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	8.629	.019	4.747	8	.001	78.00000	16.43107	40.10989	115.89011
Equal variances not assumed			4.747	4.004	.009	78.00000	16.43107	32.39868	123.60132

P=0.001

Table 4a: Showing Temperatures of Ekemini Bakery at Mount Zion Calabar South.

Distance (m)	Temperature around oven (ºC)	Ambient Temperature of the Bakery (ºC)	Wind Speed inside the bakery (ms^{-1})	Body Temperature of six workers (ºC)
Source Point	161	40.2	0.83	36.2
1	120	40.5	0.95	36.8
2	100	41.3	1.10	37.0
3	80	41.7	1.16	36.3
4	60	42.4	1.29	36.7
5	40	43.0	1.36	33.9

Table 4b: Independent Samples Test of effect of heat emanating from Bakery on Health of workers (Ekemini Mount Zion)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	7.115	.028	3.677	8	.006	65.80000	17.89413	24.53606	107.06394
Equal variances not assumed			3.677	4.019	.021	65.80000	17.89413	16.20815	115.39185

P=0.006

Table 5a: Showing Temperature of Bakery with varied distance from heat source (Oven), Ambient Temperature of the Bakery and Body Temperature of six workers at Ededem (spring road)

Distance	Temperature around oven (ºC)	Ambient Temperature of the Bakery (ºC)	Wind Speed inside the bakery (ms^{-1})	Body Temperature of six workers (ºC)
Source Point	161	40.2	0.83	37.2
1	120	40.5	0.95	36.1
2	100	41.3	1.10	36.8
3	80	41.7	1.16	36.6
4	60	42.4	1.29	36.5
5	40	43.0	1.36	37.0

Table 5b: Independent Samples Test of effect of heat emanating from bakery on health of workers in Ededem (Spring Road

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
SCORE	Equal variances assumed	9.402	.015	5.101	8	.001	72.20000	14.15415	39.56047	104.83953
	Equal variances not assumed			5.101	4.014	.007	72.20000	14.15415	32.95424	111.44576

P= 0.001

Table 6a: Showing Temperature of Bakery with varied distances from heat source (Oven), Ambient Temperature of the Bakery, Wind Speed inside the bakery and Body Temperature of six workers at Daybreak Bakery (Chamley Street).

Distance (m)	Temperature (ºC)	Ambient Temperature (ºC)	Wind Speed (ms^{-1})	Body Temperature of six workers (ºC)
Source Point	180	43.8	1.73	36.6
1	120	44.3	1.82	37.0
2	110	44.5	1.85	37.0
3	100	44.3	1.82	36.8
4	80	45.2	1.97	36.7
5	40	45.1	1.96	36.9

Table 6b: Independent Samples Test of effect of heat emanating from Daybreak bakery on health of workers (Chamley Street)

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	5.515	.047	5.203	8	.001	81.00000	15.56856	45.09884	116.90116
Equal variances not assumed			5.203	4.071	.006	81.00000	15.56856	38.07149	123.92851

P 0.001

The p-value or significant value of 0.005, 0.001, 0.006, 0.001, and 0.005 for tables 2b – 6b respectively are less than the significance value of 0.05. With this result, the hypothesis that states that there is no significant influence of thermally induced radiation emanating from bakery ovens on the physiology of workers is rejected. Hence, there is a significant influence of thermally induced radiation emanating from bakery ovens on the health of workers. These results of statistical analysis conform to physical temperature data obtained in all locations. The temperature data are beyond the acceptable temperature limit for smooth functionality of human physiology and comfort as recommended by World Health Organization (WHO) in table 1(comfort temperature 20-29 ^{o}C).This result is in agreement with Beheshti et al., 2015; Kamgba, 2019 on performer loss on workers due to heat stress and induced temperature baseline data. The result is in agreement with bioheat model exemplified by lumped model; segmented model and multi-dimensional models.

*Conclusion***:** In a survey to investigate consequences of thermal induced radiation from six bakery ovens on the physiology of its workers in Calabar, CRS, Nigeria conducted using in-situ measurement approach, it was noted that; both ambient temperature and wind speed in the bakeries increased. The result analysis shows a significant effect on the health of the workers due to excessive heat. The exposure of workers to thermal radiation in all the bakeries under study exceeded the WHO exposure limit for comfort as all bakeries visited used firewood oven.

REFERENCES

Arora, AR; Rama Raju, AR (2006). Dictionary of Physics. EPP Books Services Nig. ltd Ist edition.

Beheshti, MH; Boroumand, NE; Bahalgerdy, B; Mehrafshan, F; Zamani, AA (2016). Performance loss among workers due to eat stress in High-Temperature work place. *JOHE spring.* 4(2).

Brotherhood, JR (1987). The practical Assessment of Heat Stress. In J. R. S. Hales & D. A. B. Richards (Eds.), Heat Stress: *Phy. Exertion and Envr*. *Elsevier Sci. Publishing* New York, (451-468).

Edet, CO; Eno, EE; Ettah, EB; Kamgba, FA (2017). Seasonal Variation of Radio Refractivity in Calabar Nigeria. *Int. J. Sci. Res. Engr. Tech.* 6 (6). 670-673

Elieser, K (1992). Relationship of Physiological Strain to Change in Heart Rate during Work in Heat, (33) 701-708. Yoran Epstein; Daniel. SM (2006). Thermal Comfort and the heat Stress Indices, *Industrial health,* (44), 388-398

Epstein, Y; Daniel. SM (2006). Thermal Comfort and the heat Stress Indices, *Industrial health,* (44), 388-398

Eoman, CO; Akpoborie, IA; Akporhonor (2008).The oil and gas industry and the Niger Delta: Implications for the environment. *J. of Apld Sci and envr. Mgt.* 12(4), 29-37.

Kamgba, FA (2019): Estimation of background induced temperature in and around Bakery ovens for selected lacation in Calabar. *Asian J. of Adv. Research and Repor*t. 4(2), 1-10.

Kamgba, FA; Edet, CO; Njok, AO (2017). Effects of Some Meteorological Parameters on Wind Energy Potential in Calabar, Nigeria, *Asian J. of Phy. Chem. Sc.* (1), 1-7

Kjellstrom, T; Holmer, I; /lemke, B (2009).Workplace heat stress, health and productivity – an increasing change for low and middle income endners. *Global Health Action and Coaction pubishing.*

Golbabaei, F; Omidvari, M (2008). Man and thermal environment. 2nd ed. Tehran: Univ. of Tehran Publ