AMERICAN JOURNAL OF AGRICULTURAL SCIENCE, ENGINEERING AND TECHNOLOGY (AJASET)

ISSN: 2158-8104 (ONLINE), 2164-0920 (PRINT)

VOL: 5 ISSUE: 2 (2021)

PUBLISHED BY: E-PALLI, FLORIDA, USA

The American Journal of Agricultural Science, Engineering and Technology (AJASET) is blind peer reviewed international journal publishing articles that emphasize research, development and application within the fields of agricultural science, engineering and technology. The AJASET covers all areas of Agricultural Science, Engineering and Technology, publishing original research articles. The AJASET reviews article within approximately two weeks of submission and publishes accepted articles online immediately upon receiving the final versions.

Published Media: ISSN: 2158-8104 (Online), 2164-0920 (Print).

Frequency: 2 issues per year (January, July)

Area of publication: Agricultural Science, Engineering and Technology. The subjects covered by the journal includes but not limited to:

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Agricultural Engineering
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EVALUATION OF HEAT STRESS ON BAKERY WORKER IN MAKURDI BENUE STATE, NORTH EAST NIGERIA

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DOI: https://doi.org/10.5281/zenodo.5372151

ABSTRACT

Nigeria being a tropical nation with high temperature and some Nigerian bakeries use mud oven which expose workers to direct contact with heat increasing their risk of heat stress. This research work tends to evaluate heat stress on bakery workers in Makurdi, Benue State. Forty questionnaires were validly filled and handed in from the workers at the various bakeries. Data such as age, duration of exposure as well as heat stress estimation and satisfaction level were filled in and data were analysis using statistics and results shows that heat stress reduces efficiency and productivity in workers poses health risk in workers such as heat cramps, heat rashes and in severe cases even heat stroke which may threaten the life of these workers. The results from measurements in this work has shown that bakery workers in Makurdi metropolis are highly exposed to heat stress and are likely to experience one disorder or the other with possible death consequences. It was also found that heat stress is often an overlooked problem as most workers lacked proper knowledge of control measures and employers have made little or no effort to prevent heat stress disorders.

Keywords: Bakery workers, Heat exposure, Heat stress, Oven, Temperature index, Wet bulb globe.

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INTRODUCTION

Heat is a form of energy characterized by an increase or a decrease in temperature, Heat may be defined as energy in transit from a high temperature object to a lower temperature object. Stress can be defined as the brain's response to any demand. Heat stress occurs when the body’s means of controlling its internal temperature starts to fail. Air temperature, work rate, humidity and work clothing are all factors which can cause heat stress. Climate in the work environment is an important factor in determining the physical comfort satisfaction of workers, and their comfort affects job satisfaction and performance. There are four primary variables that define climate, namely air temperature, humidity (relative humidity), air movement and radiation from surrounding objects including the sun. Environmental conditions cause body temperatures to rise above or fall below normal, there is a risk of either heat stress or cold stress. Nigeria being a tropical nation with high temperature and some Nigerian bakeries use mud oven which expose workers to direct contact with heat increasing their risk of heat stress. Heat stress reduces efficiency and productivity in workers poses health risk in workers such as heat cramps, heat rashes and in severe cases even heat stroke which may threaten the life of these workers. This research work is to establish the inherent heat stress amongst bakery workers and proffer solutions or suggestions to mitigate them. This work will help employers and owners of bakery to be more conscious of their workers’ health and see ways to improve the conditions of their facility to reduce heat stress. It would also create awareness amongst workers to be mindful of their state of health as they work in high heat intensity facilities. It would also help engineers look at ways to create or remodel bakery facilities and equipment’s in order to reduce the temperature around the working areas in bakeries thereby reducing heat stress.

LITERATURE REVIEW

The art of baking was brought into Nigeria by some freed Negroes who were well established as independent artisans in various trades. These Negroes educated and Christianized settled first in Lagos where baking was carried out in their homes until about 1900. Then, commercial bakeshops began to spring up. The eating of bread which was the main baked product at that time disseminated first along the coastline (Ports) Warri, Calabar, Port-Harcourt, and then inland Onitsha etc. The continued growth of the bakery industry necessitated the establishment of flour mill in Nigeria by the Nigerian government. A baker is a worker who mixes flour, salt, yeasts, spices, sugar, and other ingredients to prepare dough, batter, fillings, etc., which are then formed into bread, cakes, rolls, etc., and baked in an oven. Their work environment is an important determinant of health; it can influence health positively or negatively, and for most people, work is essential for economic, social as well as physical wellbeing.

Occupational heat exposure is of rising concern globally with climate change drawing more consideration to this issue. Whether in outdoor or indoor situations, working in excessive heat environments (temperatures exceeding 35° Celsius) poses risks to workers' health and reduces labor productivity. Excessive heat exposure creates an occupational hazard of high concern, particularly in indoor and outdoor workplaces lacking effective climate control. It has been estimated that roughly 20% of the workforce hours in South East Asia were lost as a result of heat exposure. Projections for the year 2030 estimate a loss of around 70 million work life- years in labor productivity due to heat exposure and a loss of 880 000 work-life-years due to occupational heat stroke mortality, in indoor and outdoor workplaces.

Occupational health researchers have focused on heat stress in outdoor workers in the field of agriculture, construction, farming, and fishing, who are particularly vulnerable due to constant exposure to heat, especially in hot or humid weather conditions. Indoor workers are also at risk if temperatures in their work environment are poorly regulated. The Occupational Health and Safety Administration (OSHA) has identified indoor industries at risk of experiencing heat related illnesses due to the presence of heat-generating appliances; these include bakeries, kitchens, laundries, and furnaces. Further research is needed to quantify the risk of heat exposure and heat-related illnesses among indoor workers in various professions, including bakery workers. In addition to measurements of indoor temperatures, additional assessments are needed, such as personal factors and work tasks that may impact risks associated with indoor heat exposure.

Heat stress experienced in hot working environments occurs when the body temperature exceeds 38°C, resulting in health symptoms, such as dry skin, chills, high body temperature, confusion, dizziness, fainting, fatigue, weakness, nausea, and muscle cramps. Other heat stress-related health conditions include heat stroke, heat exhaustion, heat syncope, and heat cramps. In addition, extreme heat has been associated with mental health effects. A systematic review conducted in 2018 shows evidence of a positive relationship between heat exposure and occupational injuries, mainly caused by fatigue, reduced psychomotor performance, loss of concentration, and reduced alertness. Despite the risks posed by heat stress, work systems have increasingly encouraged workers to ignore symptoms of heat-related illnesses, to maintain the work pace and avoid breaks and work interruptions. Temperatures and humidity in indoor work environments may increase during hot and humid seasons, especially in workplaces that lack adequate ventilation or air conditioning. The presence of drinking water and emergency procedures are also factors affecting workers' responses to heat exposure. Risk factors for heat stress include individual susceptibility, such as age and gender, along with workers' hydration levels, workplace and environment temperature levels, and work rate and activities. Moreover, the effects of hot and humid working conditions may exacerbate if workers are unaware of heat-related illnesses and their prevention. The management of heat-related occupational exposures must involve risk assessment and control measures at the level of the work, the workers, and the work environment. However, regulations in low and middle-income countries (LMIC) are challenged by socioeconomic factors and lack of adequate infrastructure, frameworks, and technical expertise.

Moreover, the tasks performed in bakeries subject workers to high levels of heat exposure resulting in health impacts if not properly controlled. Most of the literature on bakery workers have focused on industrialized bakeries studying the respiratory effects of exposure to flour dust or skin irritation and allergies. Other publications have also studied and assessed ergonomic hazards, mainly musculoskeletal disorders, and mental and self-rated health among bakery workers. Few studies exploring heat exposure among bakery workers documented elevated heat stress exposures among those workers. Research has also distinguished the working conditions and risks between traditional bakeries and industrialized bakeries. A recent study showed that workers in traditional bakeries are exposed to higher levels of heat stress when compared to workers in industrial bakeries. In addition, the incidence of heat stress among bakery workers in traditional bakeries has been shown to be 3.3% higher than those in industrial bakeries.

MATERIALS AND METHOD

Heat stress checklist

An initial survey was carried out in each of the bakeries with the help of the heat stress checklist to ascertain their working condition. Each parameter is given a risk score and a brief description to help understand the score. The parameters that influences heat stress such as air temperature, radiant temperature, air velocity, humidity, clothing and metabolic rate were carefully observed as then given a risk score on the checklist according to how it is described by the checklist.

Questionnaires

The questionnaire was divided into 3 sections. Section A required that participants indicate their demographic information including their age, sex, job description. Section B assessed their work environment by asking participant to give information about how long they have been working in the bakery, how long they work and their shifts as well as their perception of the thermal environment and how much it affects them. Section C asked about experienced heat disorder and how often as well as if they have any form of education on heat stress and preventive measures.

Measurements of environmental parameters

Measurement was taken using a certified ADARSH wet bulb and dry bulb thermometer. Measurement was taken during 10:00am and 2:00pm when most bakeries usually start the actual baking process. The hygrometer was first recalibrated, and then measurement was taken at three levels, above the head, at chest and below the waist level and the average was calculated.

Air temperature measurement was gotten reading the dry bulb thermometer and Relative humidity is determined by finding the differences in degrees between the dry-bulb and wet-bulb readings on the horizontal scale at the top, and then reading off where this column intersects the horizontal row containing the dry-bulb temperature reading on a hygrometric chart.

Conversion tables

To determine the level of heat stress an operator is subjected to, an approximation conversion table by U.S Bureau of Meteorology was used in determining the WBGT. This table does not take the variation in the intensity of solar radiation or of wind speed into account, and assures a moderately high radiation level in light wind conditions.

$$\mathbf{WBGT = 0.567 \times Ta + 0.393 \times e + 3.94} \quad \text{.................................(1)}$$

where:

Ta= Dry bulb temperature (°C)

e= Water vapour pressure (hPa) [humidity]

$$e = \frac{rh}{100} \times 6.105 Exp \frac{17.27Ta}{237.7+Ta} \quad \text{.. (2)}$$

Where rh = relative humidity (%)

The conversion table makes use of temperature and relative humidity to determine the WBGT. The wet bulb temperature, dry bulb temperature and relative humidity for the work environment were measured and used on the table to identify the prevailing WBGT. From IS0 7243, heat stress occurs when WBGT≥31˚C.

Wet Bulb Globe Temperature (WBGT) from Temperature and Relative Humidity

Temperature (°C)

Relative Humidity (%)	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
0	15	16	16	17	18	18	19	19	20	20	21	22	22	23	23	24	24	25	25	26	27	27	28	28	29	29	30	31	31	32	32
5	16	16	17	18	18	19	19	20	21	21	22	22	23	24	24	25	26	26	27	27	28	29	29	30	31	31	32	33	33	34	35
10	16	17	17	18	19	19	20	21	21	22	23	23	24	25	25	26	27	27	28	29	30	30	31	32	32	33	34	35	36	36	37
15	17	17	18	19	19	20	21	21	22	23	23	24	25	26	26	27	28	29	29	30	31	32	33	33	34	35	36	37	38	39	
20	17	18	18	19	20	21	21	22	23	24	24	25	26	27	27	28	29	30	31	32	32	33	34	35	36	37	38	39			
25	18	18	19	20	20	21	22	23	24	24	25	26	27	28	28	29	30	31	32	33	34	35	36	37	38	39					
30	18	19	20	20	21	22	23	23	24	25	26	27	28	29	29	30	31	32	33	34	35	36	37	39							
35	18	19	20	21	22	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39								
40	19	20	21	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39									
45	19	20	21	22	23	24	25	26	27	27	28	29	30	32	33	34	35	36	37	38											
50	20	21	22	23	23	24	25	26	27	28	29	30	31	33	34	35	36	37	39												
55	20	21	22	23	24	25	26	27	28	29	30	31	32	34	35	36	37	38													
60	21	22	23	24	25	26	27	28	29	30	31	32	33	35	36	37	38														
65	21	22	23	24	25	26	27	28	29	31	32	33	34	36	37	38															
70	22	23	24	25	26	27	28	29	30	31	33	34	35	36	38	39									WBGT > 40						
75	22	23	24	25	26	27	29	30	31	32	33	35	36	37	39																
80	23	24	25	26	27	28	29	30	32	33	34	36	37	38																	
85	23	24	25	26	28	29	30	31	32	34	35	37	38	39																	
90	24	25	26	27	28	29	31	32	33	35	36	37	39																		
95	24	25	26	27	29	30	31	33	34	35	37	38																			
100	24	26	27	28	29	31	32	33	35	36	38	39																			

Note: This table is compiled from an approximate formula which only depends on temperature and humidity. The formula is valid for full sunshine and a light wind

Figure 1: Conversion table (source: U.S bureau of meteorology)

Statistical analysis

Data received from the field was analyzed using Excel 2007 (Analysis Tool Pack) to test the hypothesis. With the help of MINITAB statistical software package, mean & standard deviation, & coefficient of co-relation were used for statistical analysis.

RESULTS

This research was conducted in ten bakeries of which two used the traditional mud oven and eight used electrically powered oven in carrying out their work. Forty workers filled out questionnaires about their psychological description of their working conditions as well as other details. This is the results of the various methods used to conduct this research.

Heat stress checklist

The Mean Score of the Heat Stress Factors (Parameters) using Heat Risk Assessment Checklist is as shown in table 1 and 2.

Questionnaire and observation

Forty questionnaires were validly filled and handed in from the workers at the various bakeries. Data such as age, duration of exposure as well as heat stress estimation and satisfaction level were filled in. Table 3 shows that the participants are from all age group while Table 4 shows the duration which they have worked in the bakery. Table 5 gives us the psychological description given by the workers of the heat stress they are faced with and Table 6 tells us how much the heat stress affects their task in terms of their job satisfaction. Table 7 is derived from personal observation of the relevant positions available in the bakery that are in risk of heat stress It was observed that most bakeries where this research was conducted had no personal protective clothing or heat-conserving clothing. Rather, they either wear light clothing or are half-naked.

Measurements of environmental parameters

Two major hot rooms were identified at the bakery and these are (1) the furnace – which seemed to be an open space housing the oven and in some cases also the generator. This is where baking is actually carried out (2) the kneader – this is a closed room, this is where mixing, milling and pounding takes place before it is kept to rise and subsequently sent to be baked. Relative humidity and air temperature were measured as used to calculate the heat load the bakery workers are subjected to. The computed result is shown in tables 8 and 9.

Table 1: Age distribution of participants

Age	Number of workers	Percentage
11-20	3	7.5%
21-30	25	62.5%
31-40	10	25.0%
41-50	2	5.0%
Total	**40**	

Table 2: Experience on the job

Number of workers	Duration
4	Below 1 year
16	1 – 5 years
11	6 – 10 years
7	11 – 15 years
2	16 – 20 years

Table 3: workers heat level rating

Heat level description	Workers	Percentage
5	3	7.5%
4	13	32.5%
3	23	57.5%
2	1	2.5%
1	0	0.0%
Total	**40**	

Table 4: Heat level satisfaction

Satisfaction level	Workers	Percentages
5	0	0.0%
4	9	22.5%
3	17	42.5%
2	11	27.5%
1	0	0.0%
Total	**40**	

Table 5: Tasks and their estimated metabolic work rate

Job description	Metabolic work rate (Wm^{-2})
At the furnace	130
Milling	100
Pounding	110
Mixing	120

Table 6: Heat stress at the furnace

Bakery	**Heat source**	**Air temperature**	**Relative humidity**	**Heat stress furnace**	**Exposure**	**Source of ventilation**
A	Electric oven	35.5˚C	66	**39.00**	5hrs	Open air
B	Electric oven	35.5˚C	63	**38.33**	4hrs	Open air
C	Mud oven	36.0˚C	69	**40.40**	10hrs	Open air
D	Electric oven	34.4˚C	66	**37.50**	7hrs	Open air
E	Electric oven	36.0˚C	63	**39.00**	10hrs	Open air
F	Electric oven	34.5˚C	66	**37.63**	5hrs	Open air
G	Electric oven5	36.0˚C	50	**35.98**	5hrs	Open air
H	Mud oven	32˚C	60	**33.26**	3hrs	Open air
I	Electric oven	34.4˚C	66	**37.50**	8hrs	Open air
J	Electric oven	35.5˚C	62	**38.10**	5hrs	Open air

Table 7: heat stress at the kneader

Bakery	Air temperature (˚C)	Relative humidity	**Heat stress at kneader**	working hours	Source of heat	Ventilation
A	36.5	66	**40.41**	6hrs	miller	none
B	36	67	**39.93**	7hrs	miller	none
C	38	68	**43.12**	6hrs	miller	none
D	36	69	**40.40**	7hrs	miller	none
E	36.5	66	**40.41**	6hrs	miller	none
F	35	68	**38.75**	6hrs	miller	none

G	37.5	63	**41.10**	7hrs	miller	none
H	34	62	**36.13**	4hrs	miller	none
I	36	69	**40.40**	8hrs	miller	none
J	37	64	**40.64**	6hrs	miller	none

Statistical analysis

Table 8: Descriptive statistics table

	Air temperature (oven) ˚C	Air temperature (kneader) ˚C	Relative humidity (oven)	Relative humidity (kneader)	Heat stress index (oven)	Heat stress index (kneader)
N	10	10	10	10	10	10
Min	32	38	50	62	33.26	36.13
Max	36	34	69	69	40.40	43.12
Mean	34.98	36.25	63.1	66.2	37.67	40.13
S.D.	1.23450	1.16070	5.27994	2.48551	1.94293	1.77602

Table 9: Analysis of variance for WBGT (kneader)

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F_{cal}	F_{tab}
Between Groups	16.9874	9	1.887489	0.078832	3.020383
Within Groups	239.4319	10	23.94319		
Total	256.4193	19			

Table 10: Analysis of variance for WBGT (oven)

Source of Variation	Sum of Square	Degree of Freedom	Mean Square	F_{cal}	F_{tab}
Between Groups	14.19404	9	1.577116	0.036602	3.020383
Within Groups	430.8873	10	43.08873		
Total	445.0813	19			

DISCUSSION

Table 1. shows the different age groups workers belong to but the maximum number of workers are in the age group of 21-30 & 31-40 (total 87.5 %.). Age is one of the important when considering heat stress especially in determining heat strain. The older a person is the more likely they are to suffer from the effect of heat; Particular consideration should be given to individuals over 45 years of age. It is not advisable to post persons over 50 years of age for strenuous jobs in hot environment. But 2% of workers were in the age group of 41-50 years working in hot environment. For these employees there is a need to monitor the body core temperature, heart rate, rest pause etc. at workplace. However, there is a definite decline in maximal work capacity with age. The fall in maximal cardiac output with age probably contributes to reduced work capacity and greater susceptibility to heat injury as well.

From table 2, most workers (90%) have spent over a year at their job and the 10% have spent more than 3 weeks, hence could also be said to be acclimatized. Before acclimatizing to working under hot conditions as well as returning during breaks from duty, participants reported cases of illnesses as well as symptoms of heat stress. Illnesses were ranging from minor fever to rare cases of yellow fever, while symptoms of heat stress such as fatigue, heat rash, headaches, heat cramps seemed to occur on daily basis or periodically as the case may be. Although no worker had a medically reportable case or severe symptoms of heat illness which caused them to cease work, their symptoms indicated that the physiological systems of the body were struggling to meet the demands of thermoregulation. Therefore, the primary avenue for reducing heat illness symptoms arising from this program of research is to improve the workers' hydration status and a point worth noting is that none of these bakeries had a well-organized system providing water for workers, most of the workers had to buy their own during break time which increases risk factor.

Table 4 shows the assessment of the workers' heat rating during the baking task obtained from data collected through questionnaires. 97.5% of the respondents complained of feeling hot during the frying process, of which 40% rated the heat level as very high, and were exposed to this level of heat for a minimum of four hours.

Table 5 shows that while most are uncomfortable with the heat level, it doesn't have much effect to their job attesting to the fact that they are acclimatized to the working conditions.

Table 6 The values measured and calculated show that those at the kneader have a higher risk factor than those working at the oven. This is very unlikely hypothetically, since standing nearer to the oven sends direct heat to the worker but this was the case in bakeries visited due to 2 reasons. First, the oven is located in an open space with access to open air for ventilation while the kneader is a roomy space with very few windows for ventilation. This was said to be needed to help the bread rise faster. Secondly the kneader has an additional heat load coming from the milling machine as well as it was over populated.

Table 7 Few workers worked at the oven compared to the millers, mixers as well as the pounders who work at the kneader resulting in higher temperature as well as higher humidity. This gives an average of 38mins for those working in the oven and 29mins for those working at the kneader which implies that anything further than this could cause serious discomfort and increase risk factor. According to interviews as well as reports, all bakery workers work more than the tolerance time with some working more than six hours with a 1hr – 2hr break.

Table 8 Statistically, using the Pearson's correlation test, Pearson's correlation coefficient (r) between heat stress index at the oven and ambient temperature in the oven is 0.789. Pearson's coefficient between the heat stress index at the kneader and its ambient temperature is 0.949. This is high relative to the Pearson's correlation coefficient between heat stress index at the oven and kneader and their respective relative humidity which is 0.585 and 0.421 at the oven and kneader respectively. This shows that air temperature has a higher significant value on heat stress as a rise in temperature would also increase heat stress. Relative humidity is not so significant call it depends on other factors such as water vapor pressure and air velocity.

Table 9 No significant difference between heat stress at the oven and heat stress at the kneader was found ($p>0.05$). Also relationship between air temperature and relative humidity is not statistically significant ($p>0.05$) showing that one variable does not cause the other i.e. a rise in temperature does not necessarily mean a rise in relative humidity. The mean temperature of heat stress at oven and at kneader is significantly different from the required mean ($p<0.05$).

Also, statistically significant difference was seen between WBGT average of furnace in all bakeries ($p<0.01$). This issue is because of difference in bakery equipment's and varying weather conditions during which this research was carried out.

The result of the hypothesis test using ANOVA in Table 9 and 10 indicates that there is a significant difference between the indices for different workstations at $F_{cal} < F_{tab}$.

H_o: the period (work station) the measurements were taken had no significant effect on the values collected (results obtained).

H_i: the period (work station) the measurements were taken had significant effect on the value (results obtained).

Decision: Accept H_0, if $F_{tab} < F_{cal}$, that is, the treatment has no effect on the parameter of interest. Hence H_i is rejected; Accept H_1 if $F_{tab} > F_{cal}$, that is, there is significant difference in the treatment with respect to the parameter of interest. Hence H_0 is rejected.

The Null hypothesis is, therefore, accepted. This implies that there was no significant difference in the treatment and method used in measuring the WBGT between the different bakeries.

Hence all analysis used to indicate that there is evidence of heat hazard in bakery.

CONCLUSIONS

Heat stress disorders are gentle killer diseases and must not be overlooked by those concerned in any industrial environment. In a very warm weathers like Nigeria, the concern for heat stress becomes much more stringent and should be seriously monitored. The results from measurements in this work has shown that bakery workers in Makurdi metropolis are highly exposed to heat stress and are likely to experience one disorder or the other with possible death consequences. It was also found that heat stress is often an overlooked problem as most workers lacked proper knowledge of control measures and employers have made little or no effort to prevent heat stress disorders. Further research on heat effect of heat stress (Heat strain) on bakery workers is highly recommended.

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